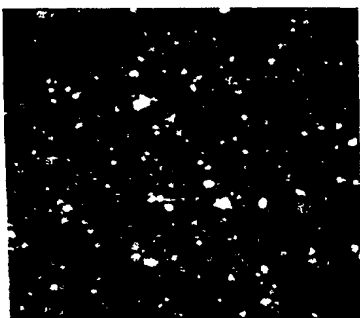

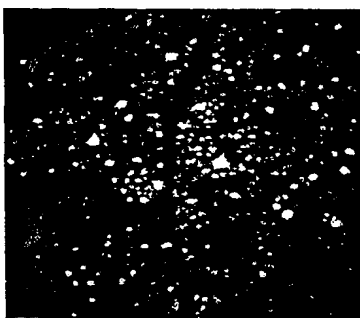




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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| <b>(51) International Patent Classification <sup>7</sup> :</b><br><br><b>A61K 31/00</b>   | <b>A2</b> | <b>(11) International Publication Number:</b> <b>WO 00/09103</b><br><br><b>(43) International Publication Date:</b> 24 February 2000 (24.02.00)  |
| <b>(21) International Application Number:</b> PCT/US99/18231<br><br><b>(22) International Filing Date:</b> 12 August 1999 (12.08.99)<br><br><b>(30) Priority Data:</b><br>09/134,471                      14 August 1998 (14.08.98)                      US<br><br><b>(71) Applicant:</b> GUILFORD PHARMACEUTICALS INC.<br>[US/US]; 6611 Tributary Street, Baltimore, MD 21224 (US).<br><br><b>(72) Inventors:</b> ROSS, Douglas, T.; 316 South Main Street, North Wales, PA 19454 (US). SAUER, Hansjorg; 10617 Lorrain Avenue, Silver Spring, MD 20901 (US). HAMILTON, Gregory, S.; 6501 Frederick Road, Catonsville, MD 21228 (US). STEINER, Joseph, P.; 4150 Louisville Road, Finksburg, MD 21048 (US).<br><br><b>(74) Agent:</b> NATH, Gary, M.; Nath & Associates, 6th Floor, 1030 15th Street, N.W., Washington, DC 20005-1503 (US).  |           | <b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).<br><br><b>Published</b><br><i>Without international search report and to be republished upon receipt of that report.</i> |
| <b>(54) Title:</b> N-LINKED SULFONAMIDES OF N-HETEROCYCLIC CARBOXYLIC ACIDS OR ISOSTERES FOR VISION AND MEMORY DISORDERS  |           |  |
| <b>(57) Abstract</b><br><br>This invention relates to novel compositions and uses of an N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof for treating a vision disorder or improving vision or treating memory impairment or enhancing memory performance in an animal.<br><br><div style="display: flex; justify-content: space-around;"> <div data-bbox="714 1165 1445 1213"> <p>GPI 1046 protects ganglion cells against degeneration due to 1 hour of retinal ischemia</p> <p>Fluorogold labelled retinal ganglion cells in wholemount, 28 days after ischemic episode</p> </div> </div> <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div data-bbox="690 1234 1047 1585">  <p>A. Labelled retinal ganglion cells in the Normal central retina</p> </div> <div data-bbox="1104 1243 1461 1585">  <p>B. 1 hour of retinal ischemia produces extensive loss of ganglion cells</p> </div> </div> <div style="display: flex; justify-content: center; align-items: flex-end; margin-top: 20px;"> <div data-bbox="901 1606 1258 1942">  <p>C. Administration of GPI 1046 1 hour before retinal ischemia and for 4 days subsequently produces significant protection of vulnerable retinal ganglion cells</p> </div> </div> |           |  |

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N-LINKED SULFONAMIDES OF N-HETEROCYCLIC CARBOXYLIC ACIDS OR ISOSTERES  
FOR VISION AND MEMORY DISORDERS

BACKGROUND OF THE INVENTION

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1. Field of Invention

This invention relates to pharmaceutical compositions and methods for treating vision loss, preventing vision degeneration, and promoting vision regeneration ("neopsis") using low molecular weight, small molecule derivatives.

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2. Description of Related Art

The visual system is composed of the eyes, ocular adnexa and the visual pathways. Dysfunction of the visual system may lead to permanent or temporary visual impairment, i.e. a deviation from normal in one or more functions of the eye. Visual impairment manifests itself in various ways and includes a broad range of visual dysfunctions and disturbances. Without limitation, these dysfunctions and disturbances include partial or total loss of vision, the need for correction of visual acuity for objects near and far, loss of visual field, impaired ocular motility without diplopia (double vision), impaired or skewed color perception, limited adaptation to light and dark, diminished accommodation, metamorphopsic

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distortion, impaired binocular vision, paresis of accommodation, iridoplegia, entropion, ectropion, epiphora, lagophthalmos, and scarring. See *Physicians' Desk Reference (PDR) for Ophthalmology*, 16th Edition, 6:47 (1988). The visual system may be adversely affected by various ophthalmologic disorders, diseases, injuries, and complications, including, without limitation, genetic disorders; [non-genetic disorders;] disorders associated with aging or degenerative diseases; disorders correlating to physical injury to the eye, head, or other parts of the body resulting from external forces; disorders resulting from environmental factors; disorders resulting from a broad range of diseases; and combinations of any of the above.

The visual system is a complex system composed of numerous components. Visual impairment can involve the entire visual system, any one component, or any combination of components, depending upon the precise nature of the circumstances. The eye is composed of a lens, which is suspended in the zonules of Zinn and is focused by the ciliary body. The ciliary body also secretes aqueous humor, which fills the posterior chamber, passes through the pupil into the anterior chamber, then drains primarily via the canal of Schlemm. The iris regulates the quantity of light



entering the eye by adjusting the size of its central opening, the pupil. A visual image is focused onto the retina, the fovea centralis being the retinal area of sharpest visual acuity. The conjunctiva is the mucus membrane which lines the eyelids and the eyeball, and ends abruptly at the limbus conjunctivae, the edge of the conjunctiva overlapping the cornea. The cornea is the clear, transparent anterior portion of the fibrous coat of the eye; it is important in light refraction and is covered with an epithelium that differs in many respects from the conjunctival epithelium.

The retina is the innermost, light sensitive portion of the eye, containing two types of photoreceptors, cones, which are responsible for color vision in brighter light, and rods, which are essential for vision in dim light but do not perceive colors. After light passes through the cornea, lens system, and the vitreous humor, it enters the retina from the inside; that is, it passes through the ganglion cells and nerve fibers, the inner and outer plexiform layers, the inner and outer nuclear layers, and the internal and external limiting membranes before it finally reaches the layer of photoreceptors located near the outside of the retina, just inside the outermost pigment epithelium layer. The cells of

the pigment epithelium layer act as an anatomical barrier to liquids and substances located outside of the eye, forming the "blood-retina" barrier, and provide nourishment, oxygen, a source of functionally useful substances like vitamin A, and phagocytosis of decomposition products to photoreceptor cells. There is no anatomical connection between the pigment epithelium and the photoreceptor layer, permitting separation of the layers in some pathological situations.

When rods or cones are excited by light, signals are transmitted through successive neurons in the retina itself, into the optic nerve fibers, and ultimately to the cerebral cortex. Both rods and cones contain molecules that decompose on exposure to light and, in the process, excite the nerve fibers leading from the eye. The molecule in rods is rhodopsin. The three light-sensitive molecules in cones, collectively called iodopsin, have compositions only slightly different from that of rhodopsin and are maximally excited by red, blue, or green light, respectively.

Neither rods nor cones generate action potentials. Rather, the light-induced membrane hyperpolarization generated in the outer, photosensitive segment of a rod or cone cell is

transmitted from the outer segment through the inner segment to the synaptic body by direct conduction of the electrical voltage itself, a process called electrotonic conduction. At the synaptic body, the membrane potential controls the release of an unknown transmitter molecule. In low light, rod and cone cell membranes are depolarized and the rate of transmitter release is greatest. Light-induced hyperpolarization causes a marked decrease in the release of transmitter molecules.

The transmitters released by rod and cone cells induce signals in the bipolar neurons and horizontal cells. The signals in both these cells are also transmitted by electrotonic conduction and not by action potential.

The rod bipolar neurons connect with as many as 50 rod cells, while the dwarf and diffuse bipolar cells connect with one or several cone cells. A depolarizing bipolar cell is stimulated when its connecting rods or cones are exposed to light. The release of transmitter molecules inhibits the depolarizing bipolar cell. Therefore, in the dark, when the rods and cones are secreting large quantities of transmitter molecules, the depolarizing bipolar cells are inhibited. In the light, the decrease in release of transmitter molecules from the rods and

cones, reduces the inhibition of the bipolar cell, allowing it to become excited. In this manner, both positive and negative signals can be transmitted through different bipolar cells from the rods and cones to the amacrine and ganglion cells.

As their name suggests, horizontal cells project horizontally in the retina, where they may synapse with rods, cones, other horizontal cells, or a combination of cells types. The function of horizontal cells is unclear, although some mechanism in the convergence of photoreceptor signaling has been postulated.

All types of bipolar cells connect with ganglion cells, which are of two primary types. A-type ganglion cells predominately connect with rod bipolar cells, while B-type ganglion cells predominately connect with dwarf and diffuse bipolar cells. It appears that A-type ganglion cells are sensitive to contrast, light intensity, and perception of movement, while B-type ganglion cells appear more concerned with color vision and visual acuity.

Like horizontal cells, the Amacrine cells horizontally synapse with several to many other cells, in this case bipolar cells, ganglion cells, and other Amacrine cells. The function of Amacrine cells is also unclear.

The axons of ganglion cells carry signals into the nerve fiber layer of the eye, where the axons converge into fibers which further converge at the optic disc, where they exit the eye as the optic nerve. The ganglion cells transmit their signals through the optic nerve fibers to the brain in the form of action potentials. These cells, even when unstimulated, transmit continuous nerve impulses at an average, baseline rate of about 5 per second. The visual signal is superimposed onto this baseline level of ganglion cell stimulation. It can be either an excitatory signal, with the number of impulses increasing above the baseline rate, or an inhibitory signal, with the number of nerve impulses decreasing below the baseline rate.

As part of the central nervous system, the eye is in some ways an extension of the brain; as such, it has a limited capacity for regeneration. This limited regeneration capacity further complicates the challenging task of improving vision, resolving dysfunction of the visual system, and/or treating or preventing ophthalmologic disorders. Many disorders of the eye, such as retinal photic injury, retinal ischemia-induced eye injury, age-related macular degeneration, free radical-induced eye diseases, as well as numerous other disorders, are considered to be

entirely untreatable. Other ophthalmologic disorders, e.g., disorders causing permanent visual impairment, are corrected only by the use of ophthalmic devices and/or surgery, with varying degrees of success.

5           The immunosuppressant drugs FK506, rapamycin, and cyclosporin are well known as potent T-cell specific immunosuppressants, and are effective against autoimmunity, transplant or graft rejection, inflammation, allergic responses, other autoimmune or  
10       immune-mediated diseases, and infectious diseases. It has been disclosed that application of Cyclosporin, FK-506, Rapamycin, Buspirone, Spiperone, and/or their derivatives are effective in treating some ophthalmologic disorders of these types. Several  
15       ophthalmologic disorders or vision problems are known to be associated with autoimmune and immunologically-mediated activities; hence, immunomodulatory compounds are expected to demonstrate efficacy for treating those types of ophthalmologic disorders or vision  
20       problems.

          The effects of FK506, Rapamycin, and related agents in the treatment of ophthalmologic diseases are disclosed in several U.S. patents (Goulet et al., U.S. Patent No. 5,532,248; Mochizuki et al., U.S. Patent  
25       No. 5,514,686; Luly et al., U.S. Patent No. 5,457,111; Russo et al., U.S. Patent No. 5,441,937; Kulkarni,

U.S. Patent No. 5,387,589; Asakura et al., U.S. Patent No. 5,368,865; Goulet et al., U.S. Patent No. 5,258,389; Armistead et al., U.S. Patent No. 5,192,773; Goulet et al., U.S. Patent No. 5,189,042; and Fehr, U.S. Patent No. 5,011,844). These patents claim FK506 or Rapamycin related compounds and disclose the known use of FK506 or Rapamycin related compounds in the treatment of ophthalmologic disorders in association with the known immunosuppressive effects of FK506 and Rapamycin. The compounds disclosed in these patents are relatively large. Further, the cited patents relate to immunomodulatory compounds limited to treating autoimmunity or related diseases, or immunologically-mediated diseases, for which the efficacy of FK506 and Rapamycin is well known.

Other U.S. patents disclose the use of cyclosporin, Spiperone, Buspirone, their derivatives, and other immunosuppressive compounds for use in the treatment of ophthalmologic diseases (Sharpe et al., U.S. Patent No. 5,703,088; Sharpe et al., U.S. Patent No. 5,693,645; Sullivan, U.S. Patent No. 5,688,765; Sullivan, U.S. Patent No. 5,620,921; Sharpe et al., U.S. Patent No. 5,574,041; Eberle, U.S. Patent No. 5,284,826; Sharpe et al., U.S. Patent No. 5,244,902; Chiou et al., U.S. Patent Nos. 5,198,454 and

5,194,434; and Kaswan, U.S. Patent No. 4,839,342).

These patents also relate to compounds useful for treating autoimmune diseases and cite the known use of cyclosporin, Spiperone, Buspirone, their derivatives, and other immunosuppressive compounds in treating ocular inflammation and other immunologically-mediated ophthalmologic diseases.

The immunosuppressive compounds disclosed in the prior art suppress the immune system, by definition, and also exhibit other toxic side effects. Accordingly, there is a need for non-immunosuppressant, small molecule compounds, and compositions and methods for use of such compounds, that are useful in improving vision; preventing, treating, and/or repairing visual impairment or dysfunction of the visual system; and preventing, treating, and/or resolving ophthalmologic disorders.

There are also a number of patents on non-immunosuppressive compounds disclosing methods of use for permitting or promoting wound healing (whether from injury or surgery); controlling intraocular pressure (often resulting from glaucoma); controlling neurodegenerative eye disorders, including damage or injury to retinal neurons, damage or injury to retinal ganglion cells, and macular degeneration; stimulating neurite outgrowth; preventing or reducing oxidative



damage caused by free radicals; and treating impaired oxygen and nutrient supply, as well as impaired waste product removal, resulting from low blood flow. These non-immunosuppressive substances fall into one of two  
5 general categories: naturally occurring molecules, such as proteins, glycoproteins, peptides, hormones, and growth factors; and synthetic molecules.

Within the group of naturally occurring non-immunosuppressive molecules, several hormones, growth  
10 factors, and signaling molecules have been patented for use as supplements to naturally occurring quantities of such molecules, as well as for targeting of specific cells where the particular molecule does not naturally occur in a mature individual. These  
15 patents generally claim methods of use for reducing or preventing the symptoms of ocular disease, or arresting or reversing vision loss.

Specifically, Louis et al., U.S. Patent Nos. 5,736,516 and 5,641,749, disclose the use of a glial  
20 cell line derived neurotrophic factor (GDNF) to stop or reverse the degeneration of retinal neurons (i.e. photoreceptors) and retinal ganglion cells caused by glaucoma, or other degenerative or traumatic retinal diseases or injuries. O'Brien, et al., U.S. Patent  
25 Nos. 5,714,459 and 5,700,909, disclose the use of a glycoprotein, Saposin, and its derivatives for

stimulating neurite outgrowth and increasing myelination. To stop or reverse degeneration of retinal neurons, LaVail et al., U.S. Patent No. 5,667,968, discloses the use of a variety of neurotrophic proteins, including brain-derived neurotrophic factor, ciliary neurotrophic factor, neurotrophin-3 or neurotrophin-4, acidic or basic fibroblast growth factors, interleukin, tumor necrosis factor- $\alpha$ , insulin-like growth factor-2 and other growth factors. Wong et al., U.S. Patent No. 5,632,984, discloses the use of interferons, especially interferon  $\alpha$ -2a, for treating the symptoms of macular degeneration by reducing hemorrhage and limiting neovascularization. Finally, Wallace et al., U.S. Patent No. 5,441,937, discloses the use of a lung-derived neurotrophic factor (NTF) to maintain the functionality of ciliary ganglion and parasympathetic neuron cells.

A key characteristic of factors derived from specific cell lines is their localization to specific cell lines or tissues; systemic treatment with these molecules would run a substantial risk of unintended, and potentially dangerous, effects in cell lines where the genes encoding these molecules are inactive. Similarly, hormones and growth factors often activate a large number of genes in many cell lines; again,

non-localized application of these molecules would run a substantial risk of provoking an inappropriate, and potentially dangerous, response.

5        Within the category of synthetic molecules, most of the patented compounds are immunosuppressive and disclose uses in treating inflammatory, autoimmune, and allergic responses, as discussed above. A few others are non-immunosuppressive and claim the ability to treat cellular degeneration, and in some cases  
10       promote cellular regeneration, most often in the context of their antioxidant properties.

Specifically, Tso et al., U.S. Patent No. 5,527,533, discloses the use of astaxanthin, a carotenoid antioxidant, for preventing or reducing  
15       photoreceptor damage resulting from the presence of free radicals. Similarly, Babcock et al., U.S. Patent No. 5,252,319, discloses the use of antioxidant aminosteroids for treating eye disease and injury, by increasing resistance to oxidative damage. Freeman,  
20       U.S. Patent No. 5,468,752, discloses the use of the antiviral phosphonylmethoxyalkylcytosines to reduce abnormally increased intraocular pressure.

Hamilton and Steiner disclose in U.S. Patent No. 5,614,547 novel pyrrolidine carboxylate compounds  
25       which bind to the immunophilin FKBP12 and stimulate nerve growth, but which lack immunosuppressive

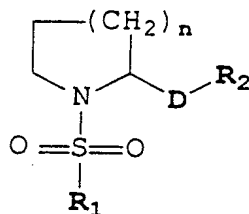
effects. Unexpectedly, it has been discovered that these non-immunosuppressant compounds promote improvements in vision and resolve ophthalmologic disorders. Yet their novel small molecule structure and non-immunosuppressive properties differentiate them from FK506 and related immunosuppressive compounds found in the prior art.

Further, these compounds may be differentiated from the non-immunosuppressive compounds used to treat vision disorders by their novel small molecule structure and their lack of general, systemic effects. Naturally occurring hormones, growth factors, cytokines, and signaling molecules are generally multifunctional and activate many genes in diverse cell lines. The present compounds do not, thus avoiding the unexpected, and potentially dangerous, side effects of systemic use. Similarly, the present compounds also avoid the potential unexpected side effects of introducing cell line-specific molecules into other cell lines were they do not naturally occur.

SUMMARY OF THE INVENTION

The present invention relates to the surprising discovery that a N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere may be useful for treating a vision disorder or improving vision or treating memory impairment or enhancing memory performance in an animal. Accordingly, novel compositions and methods of using a N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere are provided. A preferred feature of the compounds of the present invention is that they do not exert any significant immunosuppressive activity.

Preferred embodiments of this invention include methods and compositions containing a compound having the formula (I):



I

where

n is 1-3;

$R_1$  is selected from the group consisting of hydrogen,  $C_1-C_9$  straight or branched chain alkyl,  $C_2-C_9$  straight or branched chain alkenyl, aryl, heteroaryl, carbocycle, or heterocycle;

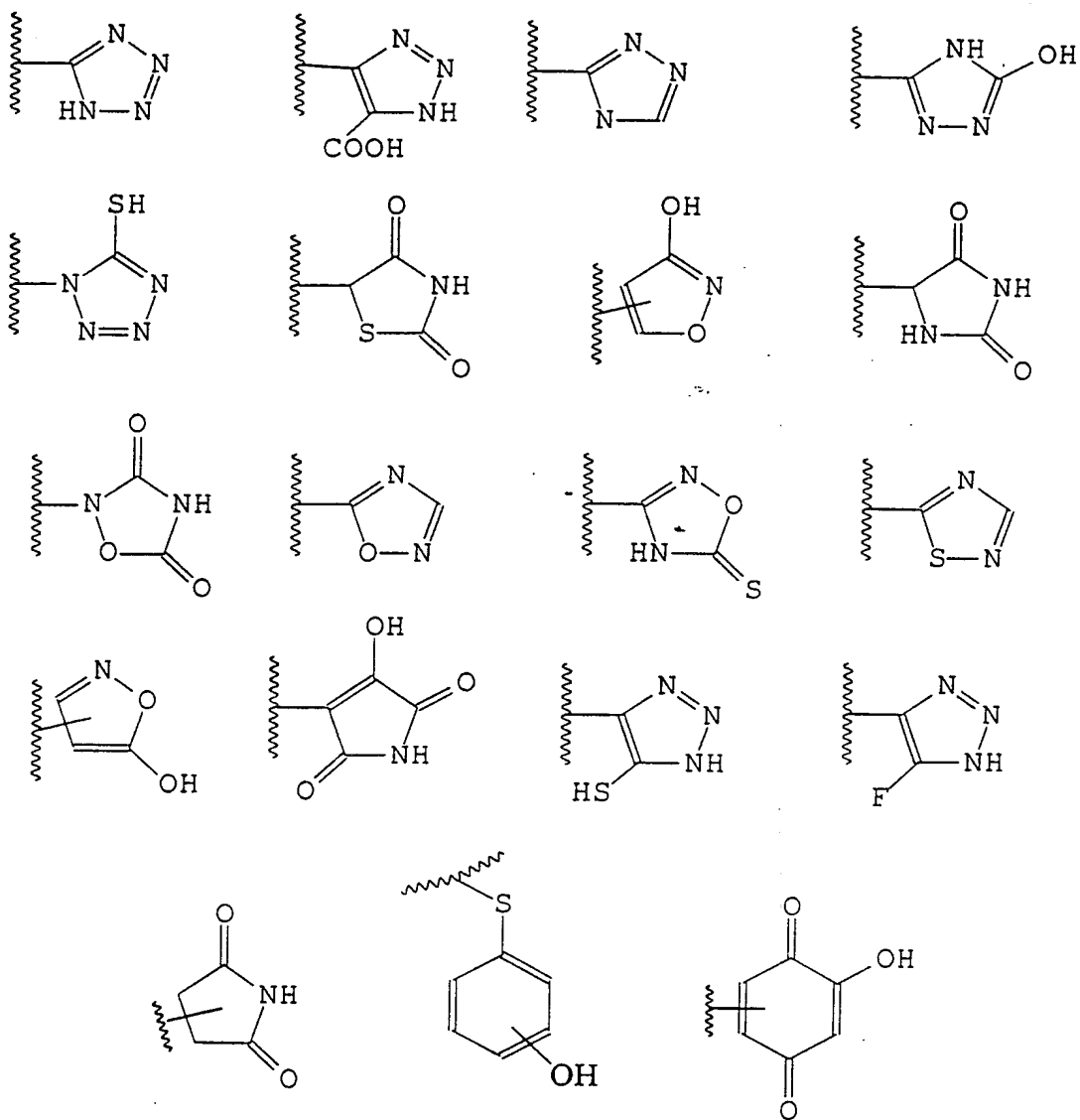
5     D is a bond, or a  $C_1-C_{10}$  straight or branched chain alkyl,  $C_2-C_{10}$  alkenyl or  $C_2-C_{10}$  alkynyl;

$R_2$  is a carboxylic acid or a carboxylic acid isostere; wherein said alkyl, alkenyl, alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or carboxylic acid isostere is optionally substituted with one or more substituents selected from  $R^3$ , where

10      $R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1-C_6$  straight or branched chain alkyl,  $C_2-C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1-C_9$  straight or branched chain alkyl or alkenyl;

15     or a pharmaceutically acceptable salt, ester or solvate thereof.

20     Especially preferred embodiments of this invention are where  $R_2$  is selected from the group below:



where the atoms of said ring structure may be optionally substituted at one or more positions with  $R^3$ ,

where

5  $R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1$ - $C_6$ -straight or branched  
10 chain alkyl,  $C_2$ - $C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, and  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1$ - $C_9$  straight or branched chain alkyl or alkenyl.

Another preferred embodiment of this invention is where  $R_2$  is selected from the group consisting of -COOH,  
15 - $SO_3H$ , - $SO_2HNR^3$ , - $PO_2(R^3)_2$ , -CN, - $PO_3(R^3)_2$ , - $OR^3$ , - $SR^3$ , - $NHCOR^3$ , - $N(R^3)_2$ , - $CON(R^3)_2$ , - $CONH(O)R^3$ , - $CONHNHSO_2R^3$ , - $COHNSO_2R^3$ , and - $CONR^3CN$ .



Brief Description of the Drawings

5       Figure 1 A, B and C show that GPI 1046 protects retinal ganglion cells against degeneration following retinal ischemia.

10       Figure 2 shows that GPI 1046 prevents degeneration of optic nerve axons and myelin following retinal ischemia.

15       Figure 3 shows that GPI 1046 provides moderate protection against retinal ganglion cell death after optic nerve transection.

20       Figure 4 shows that GPI 1046 treatment duration significantly affects the process of optic nerve axonal degeneration after transection.

      Figure 5 shows that GPI 1046 treatment produces a greater effect on optic nerve axons than ganglion cell bodies.

25       Figure 6 shows that GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the proximal stump.

Figure 7 shows that FKBP-12 immunohistochemistry labels oligodendroglia (large dark cells with fibrous processes), the cells which produce myelin, located  
5 between the fascicles of optic nerve fibers, and also some optic nerve axons.

Figure 8 shows GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in  
10 the distal stump.

Figure 9 shows that 28 day treatment with GPI 1046 treatment beginning 8 weeks after onset of streptozotocin induced diabetes decreases the extent of  
15 neovascularization in the inner and outer retina and protects neurons in the inner nuclear layer (INL) and ganglion cell layer (GCL) from degeneration.

## DETAILED DESCRIPTION OF THE INVENTION

### Definitions

"Eye" refers to the anatomical structure responsible for vision in humans and other animals, and encompasses the following anatomical structures, without limitation: lens, vitreous body, ciliary body, posterior chamber, anterior chamber, pupil, cornea, iris, canal of Schlemm, zonules of Zinn, limbus, conjunctiva, choroid, retina, central vessels of the retina, optic nerve, fovea centralis, macula lutea, and sclera.

"Alkyl" means a branched or unbranched saturated hydrocarbon chain comprising a designated number of carbon atoms. For example, C<sub>1</sub>-C<sub>6</sub> straight or branched alkyl hydrocarbon chain contains 1 to 6 carbon atoms, and includes but is not limited to substituents such as methyl, ethyl, propyl, iso-propyl, butyl, iso-butyl, tert-butyl, n-pentyl, n-hexyl, and the like. It is also contemplated as within the scope of the present invention that "alkyl" may also refer to a hydrocarbon chain wherein any of the carbon atoms of said alkyl are optionally replaced with O, NH, S, or SO<sub>2</sub>. For example, carbon 2 of n-pentyl can be replaced with O to form propyloxymethyl.

"Alkenyl" means a branched or unbranched unsaturated hydrocarbon chain comprising a designated number of carbon atoms. For example, C<sub>2</sub>-C<sub>6</sub> straight or branched alkenyl hydrocarbon chain contains 2 to 6 carbon atoms having at least one double bond, and includes but is not limited to substituents such as ethenyl, propenyl, iso-propenyl, butenyl, iso-butenyl, tert-butenyl, n-pentenyl, n-hexenyl, and the like. It is also contemplated as

within the scope of the present invention that "alkenyl" may also refer to an unsaturated hydrocarbon chain wherein any of the carbon atoms of said alkenyl are optionally replaced with O, NH, S, or SO<sub>2</sub>. For example, carbon 2 of 4-pentene can be replaced with O to form (2-propene)oxymethyl.

"Alkoxy" means the group -OR wherein R is alkyl as herein defined. Preferably, R is a branched or unbranched saturated hydrocarbon chain containing 1 to 6 carbon atoms.

Aryl, heteroaryl, carbocycle, or heterocycle means a cyclic or fused cyclic ring and includes a mono-, bi- or tricyclic, carbo- or heterocyclic ring, wherein the ring is either unsubstituted or substituted in one or more position(s) with hydrogen, hydroxy, carbonyl, amino, amido, cyano, isocyano, nitro, nitroso, nitrilo, isonitrilo, imino, azo, diazo, sulfonyl, sulfhydryl, sulfoxy, thio, thiocarbonyl, thiocyano, formanilido, thioformamido, sulfhydryl, halo, haloalkyl, trifluoromethyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, alkylamino, aminoalkyl, thioalkyl, alkylthio, C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>6</sub> straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or CO<sub>2</sub>R<sup>i</sup> where R<sup>i</sup> is hydrogen or C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl and carbocyclic and heterocyclic moieties. Carbocyclic

moieties include alicyclic and aromatic structures; wherein the individual ring sizes are 5-8 members; wherein the heterocyclic ring contains 1-4 heteroatom(s) selected from the group consisting of O, N, or S; wherein aromatic or tertiary alkyl amines are optionally oxidized to a corresponding N-oxide. Examples of useful alkyl groups include, without limitation, methyl, ethyl, propyl, isopropyl, butyl, tert-butyl, n-pentyl, 2-methyl pentyl and the like. Examples of useful carbocyclic and heterocyclic moieties include, without limitation, phenyl, benzyl, naphthyl, indenyl, azulenyl, fluorenyl, anthracenyl, indolyl, isoindolyl, indolinyl, cyclohexyl, benzofuranyl, benzothiophenyl, indazolyl, benzimidazolyl, benzthiazolyl, tetrahydrofuranyl, tetrahydropyranyl, pyridyl, pyrrolyl, pyrrolidinyl, pyridinyl, pyrimidinyl, purinyl, quinolinyl, isoquinolinyl, tetrahydroquinolinyl, quinoliziny, furyl, thiophenyl, imidazolyl, oxazolyl, benzoxazolyl, thiazolyl, isoxazolyl, isotriazolyl, oxadiazolyl, triazolyl, thiadiazolyl, pyridazinyl, pyrimidinyl, pyrazinyl, triazinyl, trithianyl, indoliziny, pyrazolyl, pyrazolinyl, pyrazolidinyl, thienyl, tetrahydroisoquinolinyl, cinnolinyl, phthalazinyl, quinazolinyl, quinoxalinyl, naphthyridinyl, pteridinyl, carbazolyl, acridinyl, phenazinyl, phenothiazinyl, phenoxazinyl, and adamantyl.

"Halo" means at least one fluoro, chloro, bromo, or

iodo moiety.

The term "pharmaceutically acceptable salt, ester, or solvate" refers to salt, ester, or solvates of the subject compounds which possess the desired pharmacological activity and which are neither biologically nor otherwise undesirable. The salt, ester, or solvates can be formed with inorganic or organic acids such as acetate, adipate, alginate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, citrate, camphorate, camphorsulfonate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, fumarate, glucoheptanoate, gluconate, glycerophosphate, hemisulfate, heptanoate, hexanoate, hydrochloride hydrobromide, hydroiodide, 2-hydroxyethanesulfonate, lactate, maleate, methanesulfonate, naphthylate, 2-naphthalenesulfonate, nicotinate, oxalate, sulfate, thiocyanate, tosylate and undecanoate. Base salt, ester, or solvates include ammonium salts, alkali metal salts such as lithium, sodium and potassium salts, alkaline earth metal salts such as calcium and magnesium salts, salt with organic bases such as dicyclohexylamine salts, N-methyl-D-glucamine, and salts with amino acids such as arginine, lysine, and so forth. Also, the basic nitrogen-containing groups can be quarternized with such agents as: 1) lower alkyl halides, such as methyl, ethyl, propyl, and butyl chloride, bromides and iodides; 2)

dialkyl sulfates like dimethyl<sup>26</sup>, diethyl, dibutyl and diamyl sulfates; 3) long chain alkyls such as decyl, lauryl, myristyl and stearyl substituted with one or more halide such as chloride, bromide and iodide; and 4) aryl or arylalkyl halides like benzyl and phenethyl bromide and others.

The compounds of this invention may possess at least one asymmetric center and thus can be produced as mixtures of stereoisomers or as individual enantiomers or diastereomers. The individual stereoisomers may be obtained by using an optically active starting material, by resolving a racemic or non-racemic mixture of an intermediate at some appropriate stage of the synthesis, or by resolution of the compound of formula (I). It is understood that the individual stereoisomers as well as mixtures (racemic and non-racemic) of stereoisomers are encompassed by the scope of the present invention. The S-stereoisomer at atom 1 of formula I is a most preferred embodiment of the invention.

"Stereoisomers" are isomers that differ only in the way the atoms are arranged in space.

"Isomers" are different compounds that have the same molecular formula and includes cyclic isomers such as (iso)indole and other isomeric forms of cyclic moieties.

"Enantiomers" are a pair of stereoisomers that are non-superimposable mirror images of each other.



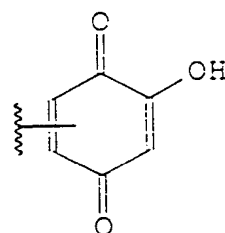
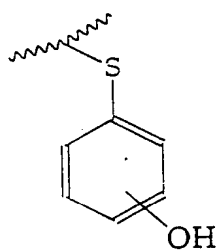
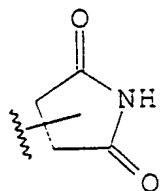
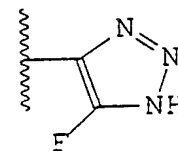
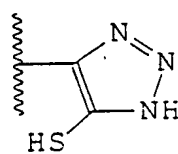
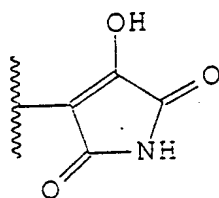
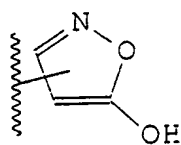
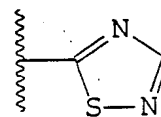
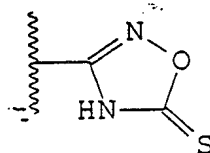
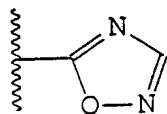
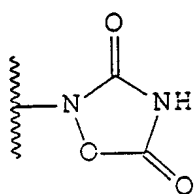
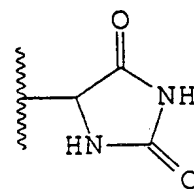
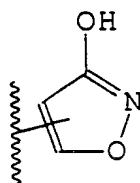
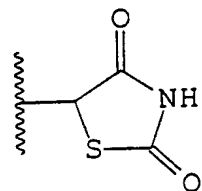
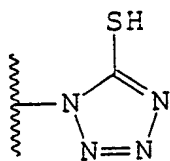
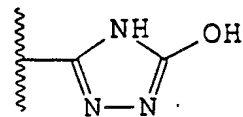
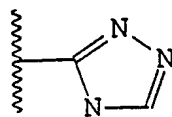
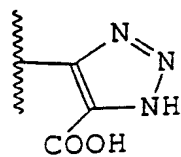
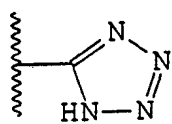
"Diastereoisomers" are stereoisomers which are not mirror images of each other.

"Racemic mixture" means a mixture containing equal parts of individual enantiomers. "Non-racemic mixture" is a mixture containing unequal parts of individual enantiomers or stereoisomers.

"Isosteres" are different compounds that have different molecular formulae but exhibit the same or similar properties. For example, tetrazole is an isostere of carboxylic acid because it mimics the properties of carboxylic acid even though they both have very different molecular formulae. Tetrazole is one of many possible isosteric replacements for carboxylic acid. Other carboxylic acid isosteres contemplated by the present invention include

$-\text{COOH}$ ,  $-\text{SO}_3\text{H}$ ,  $-\text{SO}_2\text{HNR}^3$ ,  $-\text{PO}_2(\text{R}^3)_2$ ,  $-\text{CN}$ ,  $-\text{PO}_3(\text{R}^3)_2$ ,  $-\text{OR}^3$ ,  $-\text{SR}^3$ ,  $-\text{NHCOR}^3$ ,  $-\text{N}(\text{R}^3)_2$ ,  $-\text{CON}(\text{R}^3)_2$ ,  $-\text{CONH}(\text{O})\text{R}^3$ ,  $-\text{CONHNHSO}_2\text{R}^3$ ,  $-\text{COHNSO}_2\text{R}^3$ , and  $-\text{CONR}^3\text{CN}$ .

In addition, carboxylic acid isosteres can include 5-7 membered carbocycles or heterocycles containing any combination of  $\text{CH}_2$ ,  $\text{O}$ ,  $\text{S}$ , or  $\text{N}$  in any chemically stable oxidation state, where any of the atoms of said ring structure are optionally substituted in one or more positions. The following structures are non-limiting examples of preferred carbocyclic and heterocyclic isosteres contemplated by this invention.



where the atoms of said ring structure may be optionally substituted at one or more positions with  $R^3$ . The present invention contemplates that when chemical substituents are added to a carboxylic isostere then the inventive compound retains the properties of a carboxylic isostere. The present invention contemplates that when a carboxylic isostere is optionally substituted with one or more moieties selected from  $R^3$ , then the substitution can not eliminate the carboxylic acid isosteric properties of the inventive compound. The present invention contemplates that the placement of one or more  $R^3$  substituents upon a carbocyclic or heterocyclic carboxylic acid isostere shall not be at an atom(s) which maintains or is integral to the carboxylic acid isosteric properties of the inventive compound if such a substituent(s) would destroy the carboxylic acid isosteric properties of the inventive compound.

Other carboxylic acid isosteres not specifically exemplified or described in this specification are also contemplated by the present invention.

The term "treatment" as used herein covers any treatment of a disease and/or condition in an animal, particularly a human, and includes:

(i) preventing a disease and/or condition from occurring in a subject which may be predisposed to the disease and/or condition but has not yet been diagnosed as having it;

(ii) inhibiting the disease and/or condition, i.e., arresting its development; or

(iii) relieving the disease and/or condition, i.e., causing regression of the disease and/or condition.

The system used in naming the compounds of the present invention is shown below, using a compound of formula I as an example.

A compound of the present invention, especially formula I, wherein n is 1, D is a bond, R<sub>1</sub> is phenylmethyl, and R<sub>2</sub> is -CN, is named (2S)-1-(phenylmethyl) sulfonyl-2-pyrrolidine carbonitrile.

15       "Enhancing memory performance" refers to  
improving or increasing the mental faculty by which to  
register, retain or recall past experiences,  
knowledge, ideas, sensations, thoughts or impressions.

20       "Memory impairment" refers to a diminished mental  
registration, retention or recall of past experiences,  
knowledge, ideas, sensations, thoughts or impressions.  
Memory impairment may affect short and long-term  
information retention, facility with spatial  
relationships, memory (rehearsal) strategies, and  
verbal retrieval and production. Common causes of

memory impairment are age, severe head trauma, brain  
anoxia or ischemia, alcoholic-nutritional diseases,  
and drug intoxications. Examples of memory impairment  
include, without limitation, benign forgetfulness,  
5 amnesia and any disorder in which memory deficiency is  
present, such as Korsakoff's amnesic psychosis,  
dementia and learning disorders.

"Neopsic factors" or "neopsics" refers to  
compounds useful in treating vision loss, preventing  
10 vision degeneration, or promoting vision regeneration.

"Neopsis" refers to the process of treating  
vision loss, preventing vision degeneration, or  
promoting vision regeneration.

"Ophthalmological" refers to anything about or  
15 concerning the eye, without limitation, and is used  
interchangeably with "ocular," "ophthalmic,"  
"ophthalmologic," and other such terms, without  
limitation.

20  
25 "Preventing vision degeneration" refers to the  
ability to prevent degeneration of vision in patients  
newly diagnosed as having a degenerative disease

affecting vision, or at risk of developing a new degenerative disease affecting vision, and for preventing further degeneration of vision in patients who are already suffering from or have symptoms of a degenerative disease affecting vision.

"Promoting vision regeneration" refers to maintaining, improving, stimulating or accelerating recovery of, or revitalizing one or more components of the visual system in a manner which improves or enhances vision, either in the presence or absence of any ophthalmologic disorder, disease, or injury.

"Treating" refers to:

(i) preventing a disease and/or condition from occurring in a subject which may be predisposed to the disease and/or condition but has not yet been diagnosed as having it;

(ii) inhibiting the disease and/or condition, i.e., arresting its development; or

(iii) relieving the disease and/or condition, i.e., causing regression of the disease and/or condition.

"Vision" refers to the ability of humans and other animals to process images, and is used interchangeably with "sight", "seeing", and other such terms, without limitation.

"Vision disorder" refers to any disorder that affects or involves vision, including without

limitation visual impairment, orbital disorders, disorders of the lacrimal apparatus, disorders of the eyelids, disorders of the conjunctiva, disorders of the cornea, cataracts, disorders of the uveal tract, disorders of the retina, disorders of the optic nerve or visual pathways, free radical induced eye disorders and diseases, immunologically-mediated eye disorders and diseases, eye injuries, and symptoms and complications of eye disease, eye disorder, or eye injury.

"Visual impairment" refers to any dysfunction in vision including without limitation disturbances or diminution in vision (e.g., binocular, central, peripheral, scotopic), visual acuity for objects near and far, visual field, ocular motility, color perception, adaptation to light and dark, accommodation, refraction, and lacrimation. See Physician's Desk Reference (PDR) for Ophthalmology, 16<sup>th</sup> Edition, 6:47 (1988).

#### Methods of the Present Invention.

The present invention relates to a method of treating a vision disorder, improving vision, treating memory impairment, or enhancing memory performance in an animal, which comprises administering to said animal an effective amount of a derivative.



The inventive methods are particularly useful for treating various eye disorders including but not limited to visual disorders, diseases, injuries, and complications, genetic disorders; disorders associated with aging or degenerative vision diseases; vision disorders correlating to physical injury to the eye, head, or other parts of the body resulting from external forces; vision disorders resulting from environmental factors; vision disorders resulting from a broad range of diseases; and combinations of any of the above.

In particular, the compositions and methods of the present invention are useful for improving vision, or correcting, treating, or preventing visual (ocular) impairment or dysfunction of the visual system, including permanent and temporary visual impairment, without limitation. The present invention is also useful in preventing and treating ophthalmologic diseases and disorders, treating damaged and injured eyes, and preventing and treating diseases, disorders, and injuries which result in vision deficiency, vision loss, or reduced capacity to see or process images, and the symptoms and complications resulting from same. The eye diseases and disorders which may be treated or prevented by the compositions and methods of the present invention are not limited with regard to the cause of said diseases or disorders.

Accordingly, said compositions and methods are applicable whether the disease or disorder is caused by genetic or environmental factors, as well as any other influences. The compositions and methods of the present invention are particularly useful for eye problems or vision loss or deficiency associated with all of the following, without limitation: aging, cellular or physiological degeneration, central nervous system or neurological disorder, vascular defects, muscular defects, and exposure to adverse environmental conditions or substances.

The compositions and methods of the present invention are particularly useful in correcting, treating, or improving visual impairment, without limitation. Visual impairment in varying degrees occurs in the presence of a deviation from normal in one or more functions of the eye, including (1) visual acuity for objects at distance and near; (2) visual fields; and (3) ocular motility without diplopia. See *Physicians' Desk Reference (PDR) for Ophthalmology, 16th Edition, 6:47 (1988)*. Vision is imperfect without the coordinated function of all three. *Id.*

Said compositions and methods of use are also useful in correcting, treating, or improving other ocular functions including, without limitation, color perception, adaptation to light and dark, accommodation, metamorphopsia, and binocular vision.

The compositions and methods of use are particularly useful in treating, correcting, or preventing ocular disturbances including, without limitation, paresis of accommodation, iridoplegia, entropion, ectropion, epiphora, lagophthalmos, scarring, vitreous opacities, non-reactive pupil, light scattering disturbances of the cornea or other media, and permanent deformities of the orbit.

The compositions and methods of use of the present invention are also highly useful in improving vision and treating vision loss. Vision loss ranging from slight loss to absolute loss may be treated or prevented using said compositions and methods of use. Vision may be improved by the treatment of eye disorders, diseases, and injuries using the compositions and methods of the invention. However, improvements in vision using the compositions and methods of use are not so limited, and may occur in the absence of any such disorder, disease, or injury.

The compositions and methods of the present invention are also useful in the treatment or prevention of the following non-limiting exemplary diseases and disorders, and symptoms and complications resulting therefrom.

Vision disorders include but are not limited to the following:

visual impairment, such as diminished visual

acuity for objects near and far, visual fields, and ocular motility;

orbital disorders, such as orbital cellulitis, periorbital cellulitis, cavernous sinus thrombosis, and exophthalmos (proptosis);

disorders of the lacrimal apparatus, such as dacryostenosis, congenital dacryostenosis, and dacryocystitis (acute or chronic);

disorders of the eyelids, such as lid edema, blepharitis, ptosis, Bell's palsy, blepharospasm, hordeolum (stye), external hordeolum, internal hordeolum (meibomian stye), chalazion, entropion (inversion of the eyelid), ectropion (eversion of the eyelid), tumors (benign and malignant), xanthelasma, basal cell carcinoma, squamous cell carcinoma, meibomian gland carcinoma, and melanoma;

disorders of the conjunctiva, such as pinguecula, pterygium, and other neoplasms, acute conjunctivitis, chronic conjunctivitis, adult gonococcal conjunctivitis, neonatal conjunctivitis, trachoma (granular conjunctivitis or Egyptian ophthalmia), inclusion conjunctivitis (inclusion blenorrhea or swimming pool conjunctivitis), neonatal inclusion conjunctivitis, adult inclusion conjunctivitis, vernal keratoconjunctivitis, keratoconjunctivitis sicca (keratitis sicca or dry eye syndrome), episcleritis, scleritis, cicatricial pemphigoid (ocular cicatricial

pemphigoid or benign mucous membrane pemphigoid), and subconjunctival hemorrhage;

disorders of the cornea, such as superficial punctate keratitis, corneal ulcer, indolent ulcer, recurrent corneal erosion, corneal epithelial basement membrane dystrophy, corneal endothelial cell dystrophy, herpes simplex keratitis (herpes simplex keratoconjunctivitis), dendritic keratitis, disciform keratitis, ophthalmic herpes zoster, phlyctenular keratoconjunctivitis (phlyctenular or eczematous conjunctivitis), interstitial keratitis (parenchymatous keratitis), peripheral ulcerative keratitis (marginal keratolysis or peripheral rheumatoid ulceration), keratomalacia (xerotic keratitis), xerophthalmia, keratoconus, bullous keratopathy;

cataracts, including developmental or congenital cataracts, juvenile or adult cataracts, nuclear cataract, posterior subcapsular cataracts;

disorders of the uveal tract, such as uveitis (inflammation of the uveal tract or retina), anterior uveitis, intermediate uveitis, posterior uveitis, iritis, cyclitis, choroiditis, ankylosing spondylitis, Reiter's syndrome, pars planitis, toxoplasmosis, cytomegalovirus (CMV), acute retinal necrosis, toxocariasis, birdshot choroidopathy, histoplasmosis (presumed ocular histoplasmosis syndrome), Behcet's

syndrome, sympathetic ophthalmia, Vogt-Koyanagi-Harada syndrome, sarcoidosis, reticulum cell sarcoma, large cell lymphoma, syphilis, tuberculosis, juvenile rheumatoid arthritis, endophthalmitis, and malignant melanoma of the choroid;

disorders of the retina, such as vascular retinopathies (e.g., arteriosclerotic retinopathy and hypertensive retinopathy), central and branch retinal artery occlusion, central and branch retinal vein occlusion, diabetic retinopathy (e.g., proliferative retinopathy and non-proliferative retinopathy), macular degeneration of the aged (age-related macular degeneration or senile macular degeneration), neovascular macular degeneration, retinal detachment, retinitis pigmentosa, retinal photic injury, retinal ischemia-induced eye injury, and glaucoma (e.g., primary glaucoma, chronic open-angle glaucoma, acute or chronic angle-closure, congenital (infantile) glaucoma, secondary glaucoma, and absolute glaucoma);

disorders of the optic nerve or visual pathways, such as papilledema (choked disk), papillitis (optic neuritis), retrobulbar neuritis, ischemic optic neuropathy, toxic amblyopia, optic atrophy, higher visual pathway lesions, disorders of ocular motility (e.g., third cranial nerve palsies, fourth cranial nerve palsies, sixth cranial nerve palsies, internuclear ophthalmoplegia, and gaze palsies);

free radical induced eye disorders and diseases;  
and

immunologically-mediated eye disorders and  
diseases, such as Graves' ophthalmopathy, conical  
5 cornea, dystrophia epithelialis corneae, corneal  
leukoma, ocular pemphigus, Mooren's ulcer, scleritis,  
and sarcoidosis (See *The Merck Manual*, Sixteenth  
Edition, 217:2365-2397 (1992) and *The Eye Book*,  
Cassel, Billig, and Randall, The Johns Hopkins  
10 University Press (1998)).

The compositions and methods of the present  
invention are also useful in the treatment of the  
following non-limiting eye injuries, and symptoms and  
complications resulting therefrom: conjunctival and  
15 corneal foreign body injuries, corneal abrasion,  
intraocular foreign body injuries, lacerations, lid  
lacerations, contusions, lid contusions (black eye),  
trauma to the globe, laceration of the iris, cataract,  
dislocated lens, glaucoma, vitreous hemorrhage,  
20 orbital-floor fractures, retinal hemorrhage or  
detachment, and rupture of the eyeball, anterior  
chamber hemorrhage (traumatic hyphema), burns, eyelid  
burns, chemical burns, chemical burns of the cornea  
and conjunctiva, and ultraviolet light burns  
25 (sunburn). See *The Merck Manual*, Sixteenth Edition,  
217:2364-2365 (1992).

The compositions and methods of the present

invention are also useful in treating and/or preventing the following non-limiting exemplary symptoms and complications of eye disease, eye disorder or eye injury: subconjunctival hemorrhages, vitreous hemorrhages, retinal hemorrhages, floaters, retinal detachments, photophobia, ocular pain, scotomas (negative and positive), errors of refraction, emmetropia, ametropia, hyperopia (farsightedness), myopia (nearsightedness), astigmatism, anisometropia, aniseikonia, presbyopia, bleeding, recurrent bleeding, sympathetic ophthalmia, inflammation, swelling, redness of the eye, irritation of the eye, corneal ulceration and scarring, iridocyclitis, perforation of the globe, lid deformities, exophthalmos, impaired mobility of the eye, lid swelling, chemosis, loss of vision, including partial or total blindness, optic neuritis, fever, malaise, thrombophlebitis, cavernous sinus thrombosis, panophthalmitis, infection of the meninges and brain, papilledema, severe cerebral symptoms (headache, decreased level of consciousness, and convulsions), cranial nerve palsies, epiphora (chronic or persistent tearing), copious reflux of mucus or pus, follicular subconjunctival hyperplasia, corneal vascularization, cicatrization of the conjunctiva, cornea, and lids, pannus, hypopyon, lagophthalmos, phlyctenules, rubeosis iridis, bitemporal hemianopia, and homonymous



hemianopia. See *The Merck Manual, Sixteenth Edition*, 217:2362-2363 (1992).

5           The           derivative may be administered in combination with an effective amount of one or more factor(s) useful in treating vision disorder, improving vision, treating memory impairment, or enhancing memory performance.

10           In a preferred embodiment, the factor(s) to be combined with the           derivative is/are selected from the group consisting of immunosuppressants for treating autoimmune, inflammatory, and immunologically-mediated disorders; wound healing agents for treating wounds resulting from injury or surgery; antiglaucomatous medications  
15           for treating abnormally elevated intraocular pressure; neurotrophic factors and growth factors for treating neurodegenerative disorders or stimulating neurite outgrowth; compounds effective in limiting or preventing hemorrhage or neovascularization for  
20           treating macular degeneration; and antioxidants for treating oxidative damage to eye tissues.

Pharmaceutical Compositions of the Present Invention

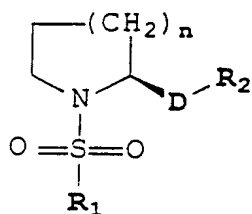
25       The present invention also relates to a pharmaceutical composition comprising:

- (i) an effective amount of a derivative for treating a vision disorder, improving vision, treating memory impairment, or enhancing memory performance in an animal; and

- (ii) a pharmaceutically acceptable carrier.

5       The derivative may be administered in combination with an effective amount of one or more factor(s) useful in treating vision disorders, improving vision, treating memory impairment, or enhancing memory performance.

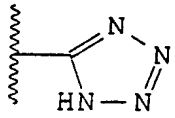
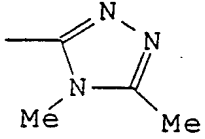
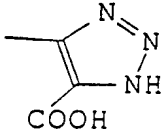
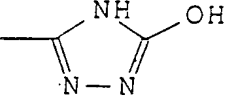
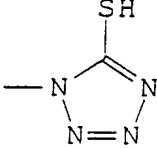
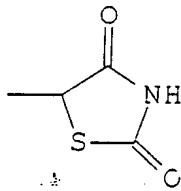
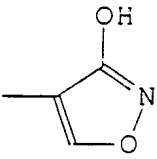
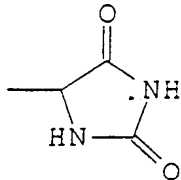
TABLE A



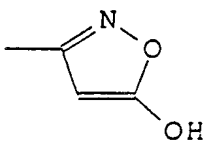
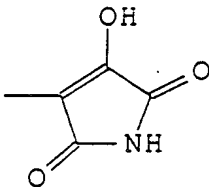
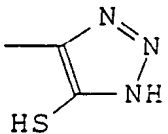
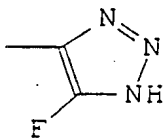
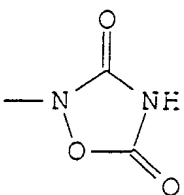
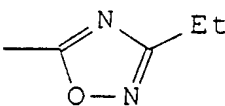
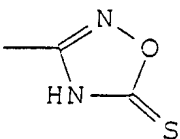
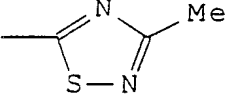
| No. | n | D                               | R2                                | R1                         |
|-----|---|---------------------------------|-----------------------------------|----------------------------|
| 1   | 1 | bond                            | COOH                              | Benzyl                     |
| 2   | 1 | bond                            | COOH                              | $\alpha$ -MethylBenzyl     |
| 3   | 1 | bond                            | COOH                              | 4-MethylBenzyl             |
| 4   | 1 | bond                            | Tetrazole                         | Benzyl                     |
| 5   | 1 | bond                            | SO <sub>3</sub> H                 | $\alpha$ -MethylBenzyl     |
| 6   | 1 | CH <sub>2</sub>                 | COOH                              | 4-MethylBenzyl             |
| 7   | 1 | bond                            | SO <sub>3</sub> HNMe              | Benzyl                     |
| 8   | 1 | bond                            | CN                                | $\alpha$ -MethylBenzyl     |
| 9   | 1 | bond                            | PO <sub>3</sub> H <sub>2</sub>    | 4-MethylBenzyl             |
| 10  | 2 | bond                            | COOH                              | Benzyl                     |
| 11  | 2 | bond                            | COOH                              | $\alpha$ -MethylBenzyl     |
| 12  | 2 | bond                            | COOH                              | 4-MethylBenzyl             |
| 13  | 2 | bond                            | COOH                              | 3,4,5-trimethoxy<br>phenyl |
| 14  | 2 | bond                            | COOH                              | Cyclohexyl                 |
| 15  | 2 | bond                            | PO <sub>3</sub> HEt               | i-propyl                   |
| 16  | 2 | bond                            | PO <sub>3</sub> HPropyl           | ethyl                      |
| 17  | 2 | bond                            | PO <sub>3</sub> (Et) <sub>2</sub> | Methyl                     |
| 18  | 2 | bond                            | OMe                               | tert-butyl                 |
| 19  | 2 | bond                            | OEt                               | n-pentyl                   |
| 20  | 2 | bond                            | OPropyl                           | n-hexyl                    |
| 21  | 1 | bond                            | OButyl                            | Cyclohexyl                 |
| 22  | 1 | bond                            | OPentyl                           | cyclopentyl                |
| 23  | 1 | bond                            | OHexyl                            | n-heptyl                   |
| 24  | 1 | bond                            | SMe                               | n-octyl                    |
| 25  | 1 | bond                            | SEt                               | n-nonyl                    |
| 26  | 2 | bond                            | SPropyl                           | 2-indolyl                  |
| 27  | 2 | bond                            | SButyl                            | 2-furyl                    |
| 28  | 2 | bond                            | NHCOMe                            | 2-thiazolyl                |
| 29  | 2 | bond                            | NHCOEt                            | 2-thienyl                  |
| 30  | 1 | CH <sub>2</sub>                 | N(Me) <sub>2</sub>                | 2-pyridyl                  |
| 31  | 1 | (CH <sub>2</sub> ) <sub>2</sub> | N(Me)Et                           | benzyl                     |
| 32  | 1 | (CH <sub>2</sub> ) <sub>3</sub> | CON(Me) <sub>2</sub>              | benzyl                     |
| 33  | 1 | (CH <sub>2</sub> ) <sub>4</sub> | CONHMe                            | benzyl                     |
| 34  | 1 | (CH <sub>2</sub> ) <sub>5</sub> | CONHEt                            | benzyl                     |
| 35  | 1 | (CH <sub>2</sub> ) <sub>6</sub> | CONHPropyl                        | 1,1-dimethylpropyl         |
| No. | n | D                               | R2                                | R1                         |
| 36  | 1 | bond                            | CONH(O)Me                         | Benzyl                     |

|    |   |                                  |                          |                        |
|----|---|----------------------------------|--------------------------|------------------------|
| 37 | 1 | bond                             | CONH(O)Et                | $\alpha$ -Methylphenyl |
| 38 | 1 | bond                             | CONH(O)Propyl            | 4-Methylphenyl         |
| 39 | 2 | bond                             | COOH                     | Benzyl                 |
| 40 | 2 | bond                             | COOH                     | $\alpha$ -Methylphenyl |
| 41 | 2 | bond                             | COOH                     | 4-Methylphenyl         |
| 42 | 1 | CH <sub>2</sub>                  | COOH                     | benzyl                 |
| 43 | 1 | (CH <sub>2</sub> ) <sub>2</sub>  | COOH                     | benzyl                 |
| 44 | 1 | (CH <sub>2</sub> ) <sub>3</sub>  | COOH                     | benzyl                 |
| 45 | 1 | (CH <sub>2</sub> ) <sub>4</sub>  | COOH                     | benzyl                 |
| 46 | 1 | (CH <sub>2</sub> ) <sub>5</sub>  | COOH                     | benzyl                 |
| 47 | 1 | (CH <sub>2</sub> ) <sub>6</sub>  | COOH                     | benzyl                 |
| 48 | 1 | (CH <sub>2</sub> ) <sub>7</sub>  | COOH                     | benzyl                 |
| 49 | 1 | (CH <sub>2</sub> ) <sub>8</sub>  | COOH                     | benzyl                 |
| 50 | 1 | (CH <sub>2</sub> ) <sub>9</sub>  | COOH                     | benzyl                 |
| 51 | 1 | (CH <sub>2</sub> ) <sub>10</sub> | COOH                     | benzyl                 |
| 52 | 1 | C <sub>2</sub> H <sub>5</sub>    | COOH                     | benzyl                 |
| 53 | 1 | 2-OH, Et                         | COOH                     | benzyl                 |
| 54 | 1 | 2butylene                        | COOH                     | benzyl                 |
| 55 | 1 | i-Pro                            | COOH                     | benzyl                 |
| 56 | 1 | tert-Bu                          | COOH                     | benzyl                 |
| 57 | 1 | 2-nitro                          | COOH                     | benzyl                 |
|    |   | Hexyl                            |                          |                        |
| 58 | 3 | (CH <sub>2</sub> ) <sub>2</sub>  | CN                       | benzyl                 |
| 59 | 1 | (CH <sub>2</sub> ) <sub>3</sub>  | CN                       | benzyl                 |
| 60 | 3 | bond                             | CONHNHSO <sub>2</sub> Me | Benzyl                 |
| 61 | 3 | bond                             | CONHNHSO <sub>2</sub> Et | $\alpha$ -Methylphenyl |
| 62 | 3 | bond                             | CONHSO <sub>2</sub> Me   | 4-Methylphenyl         |
| 63 | 2 | bond                             | CONHNHSO <sub>2</sub> Et | Phenyl                 |
| 64 | 2 | bond                             | CON(Me)CN                | $\alpha$ -Methylphenyl |
| 65 | 2 | bond                             | CON(Et)CN                | 4-Methylphenyl         |
| 66 | 1 | (CH <sub>2</sub> ) <sub>2</sub>  | COOH                     | methyl                 |
| 67 | 1 | (CH <sub>2</sub> ) <sub>3</sub>  | COOH                     | ethyl                  |
| 68 | 1 | (CH <sub>2</sub> ) <sub>4</sub>  | COOH                     | n-propyl               |
| 69 | 1 | (CH <sub>2</sub> ) <sub>5</sub>  | COOH                     | t-butyl                |
| 70 | 1 | (CH <sub>2</sub> ) <sub>6</sub>  | COOH                     | Pentyl                 |
| 71 | 1 | (CH <sub>2</sub> ) <sub>7</sub>  | COOH                     | Hexyl                  |
| 72 | 1 | (CH <sub>2</sub> ) <sub>8</sub>  | COOH                     | Septyl                 |
| 73 | 1 | (CH <sub>2</sub> ) <sub>9</sub>  | COOH                     | Octyl                  |
| 74 | 1 | (CH <sub>2</sub> ) <sub>10</sub> | COOH                     | Nonyl                  |
| 75 | 1 | C <sub>2</sub> H <sub>5</sub>    | COOH                     | Cyclohexyl             |

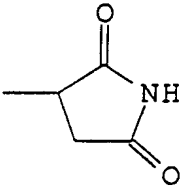
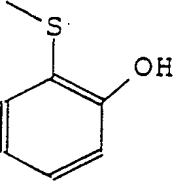
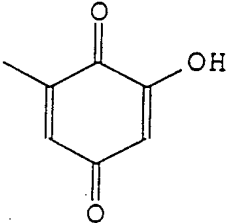
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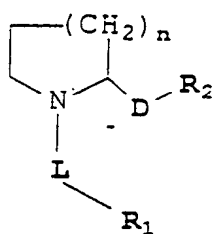
| No. | n | D    | R2  | R1     |
|-----|---|------|---|--------|
| 76  | 1 | bond |    | benzyl |
| 77  | 1 | bond |    | benzyl |
| 78  | 1 | bond |    | benzyl |
| 79  | 1 | bond |   | benzyl |
| 80  | 1 | bond |  | benzyl |
| 81  | 1 | bond |  | benzyl |
| 82  | 1 | bond |  | benzyl |
| 83  | 1 | bond |  | benzyl |

48

| No. | n | D    | R2  | R1     |
|-----|---|------|---|--------|
| 84  | 1 | bond |    | benzyl |
| 85  | 1 | bond |    | benzyl |
| 86  | 1 | bond |    | benzyl |
| 87  | 1 | bond |   | benzyl |
| 88  | 1 | bond |  | benzyl |
| 89  | 1 | bond |  | benzyl |
| 90  | 1 | bond |  | benzyl |
| 91  | 1 | bond |  | benzyl |

49

| No. | n | D    | R2   | R1     |
|-----|---|------|--|--------|
| 92  | 1 | bond |   | benzyl |
| 93  | 1 | bond |   | benzyl |
| 94  | 1 | bond |  | benzyl |
| 95  | 1 | bond | CH <sub>2</sub> OH   | benzyl |
| 96  | 1 | bond | CONH <sub>2</sub>  | benzyl |
| 97  | 1 | bond | CN   | benzyl |



| No. | n | D               | R <sub>2</sub>    | L              | R <sub>1</sub>     |
|-----|---|-----------------|-------------------|----------------|--------------------|
| 101 | 1 | CH <sub>2</sub> | OH                | 1,2-dioxoethyl | benzyl             |
| 102 | 1 | bond            | -CN               | 1,2-dioxoethyl | 1,1-dimethylpropyl |
| 103 | 1 | bond            | tetrazole         | 1,2-dioxoethyl | 1,1-dimethylpropyl |
| 104 | 2 | bond            | CONH <sub>2</sub> | 1,2-dioxoethyl | 1,1-dimethylpropyl |
| 105 | 1 | bond            | COOH              | 1,2-dioxoethyl | 1,1-dimethylpropyl |
| 106 | 2 | bond            | COOH <sup>1</sup> | 1,2-dioxoethyl | 1,1-dimethylpropyl |



Affinity for FKBP12

10           The compounds used in the inventive methods and  
pharmaceutical compositions have an affinity for the  
FK506 binding protein, particularly FKBP12. The  
inhibition of the prolyl peptidyl *cis-trans* isomerase  
activity of FKBP may be measured as an indicator of  
15           this affinity.

K<sub>i</sub> Test Procedure

          Inhibition of the peptidyl-prolyl isomerase  
(rotamase) activity of the compounds used in the  
20           inventive methods and pharmaceutical compositions can  
be evaluated by known methods described in the  
literature (Harding et al., *Nature*, 1989, 341:758-760;  
Holt et al. *J. Am. Chem. Soc.*, 115:9923-9938). These

values are obtained as apparent  $K_i$ 's.

The *cis-trans* isomerization of an alanine-proline bond in a model substrate, N-succinyl-Ala-Ala-Pro-Phe-  
5 *p*-nitroanilide, is monitored spectrophotometrically in a chymotrypsin-coupled assay, which releases *para*-nitroanilide from the *trans* form of the substrate. The inhibition of this reaction caused by the addition of different concentrations of inhibitor is  
10 determined, and the data is analyzed as a change in first-order rate constant as a function of inhibitor concentration to yield the apparent  $K_i$  values.

In a plastic cuvette are added 950 ml of ice cold assay buffer (25 mM HEPES, pH 7.8, 100 mM NaCl), 10 ml  
15 of FKBP (2.5 mM in 10 mM Tris-Cl pH 7.5, 100 mM NaCl, 1 mM dithiothreitol), 25 ml of chymotrypsin (50 mg/ml in 1 mM HCl) and 10 ml of test compound at various concentrations in dimethyl sulfoxide. The reaction is initiated by the addition of 5 ml of substrate  
20 (succinyl-Ala-Phe-Pro-Phe-*para*-nitroanilide, 5 mg/ml in 2.35 mM LiCl in trifluoroethanol).

The absorbance at 390 nm versus time is monitored for 90 seconds using a spectrophotometer and the rate constants are determined from the absorbance versus  
25 time data files.

Route of Administration

45 To effectively treat vision loss or promote  
vision regeneration, the compounds used in the  
inventive methods and pharmaceutical compositions must

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readily affect the targeted areas. For these purposes, the compounds are preferably administered [topically to the skin.]

[For topical application to the skin, the compounds can be formulated into suitable ointments containing the compounds suspended or dissolved in, for example, mixtures with one or more of the following: mineral oil, liquid petrolatum, white petrolatum, propylene glycol, polyoxyethylene polyoxypropylene compound, emulsifying wax and water. Alternatively, the compounds can be formulated into suitable lotions or creams containing the active compound suspended or dissolved in, for example, a mixture of one or more of the following: mineral oil, sorbitan monostearate, polysorbate 60, cetyl ester wax, cetearyl alcohol, 2-octyldodecanol, benzyl alcohol and water.]

Other routes of administration known in the pharmaceutical art are also contemplated by this invention.

#### Dosage

Dosage levels on the order of about 0.1 mg to about 10,000 mg of the active ingredient compound are useful in the treatment of the above conditions, with preferred levels of about 0.1 mg to about 1,000 mg. The specific dose level for any particular patient

will vary depending upon a variety of factors, including the activity of the specific compound employed; the age, body weight, general health, sex and diet of the patient; the time of administration; the rate of excretion; drug combination; the severity of the particular disease being treated; and the form of administration. Typically, *in vitro* dosage-effect results provide useful guidance on the proper doses for patient administration. Studies in animal models are also helpful. The considerations for determining the proper dose levels are well known in the art.

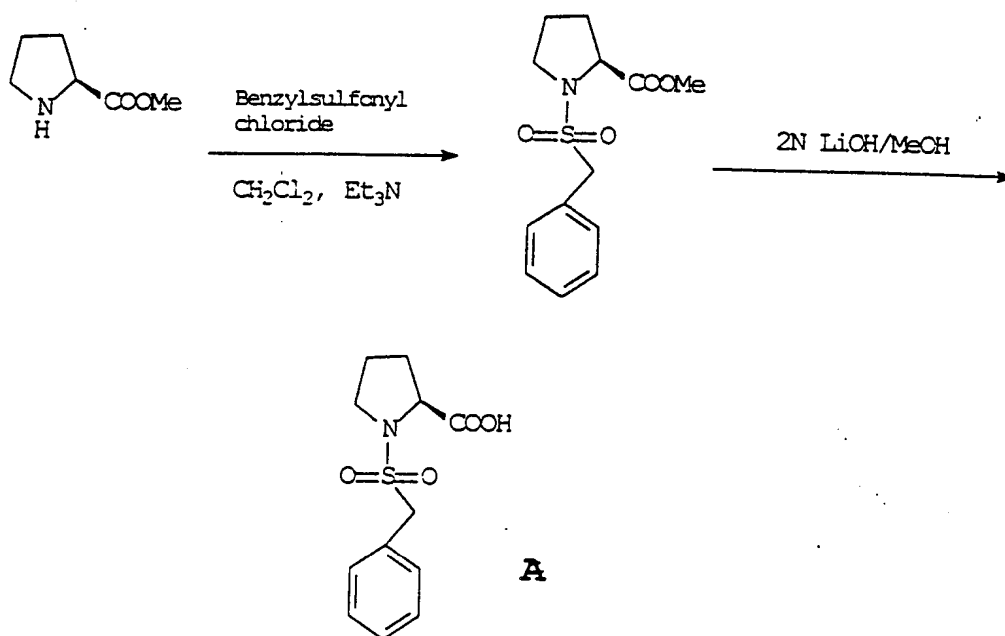
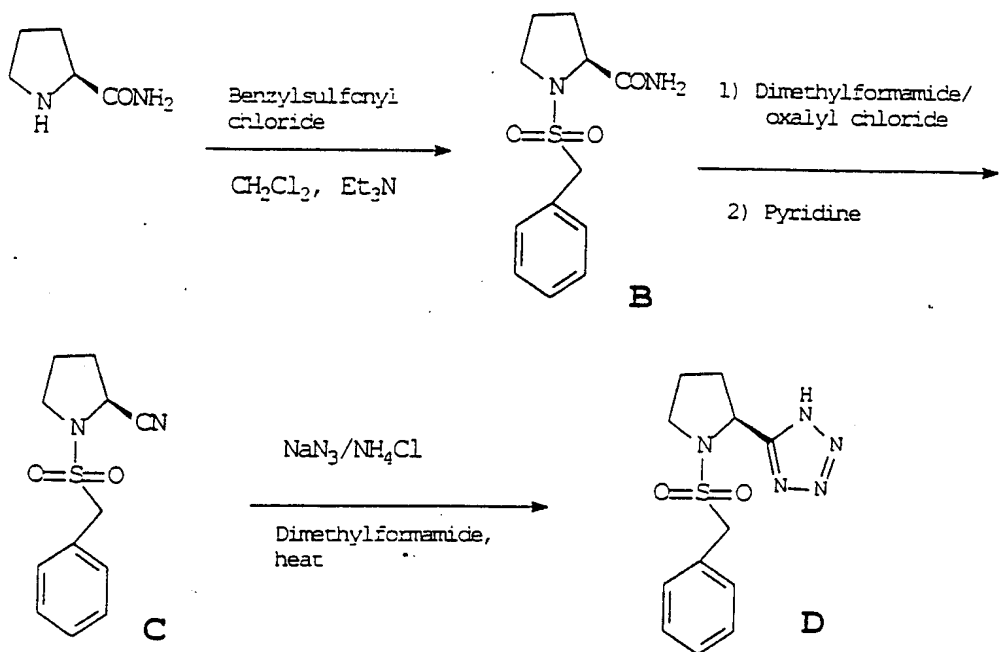
The compounds can be administered with other agents for treating vision loss, preventing vision degeneration, or promoting vision regeneration. Specific dose levels for such other agents will depend upon the factors previously stated and the effectiveness of the drug combination.

The following examples are illustrative of preferred embodiments of the invention and are not to be construed as limiting the invention thereto. All polymer molecular weights are mean average molecular weights. All percentages are based on the percent by weight of the final delivery system or formulation prepared unless otherwise indicated and all totals equal 100% by weight.

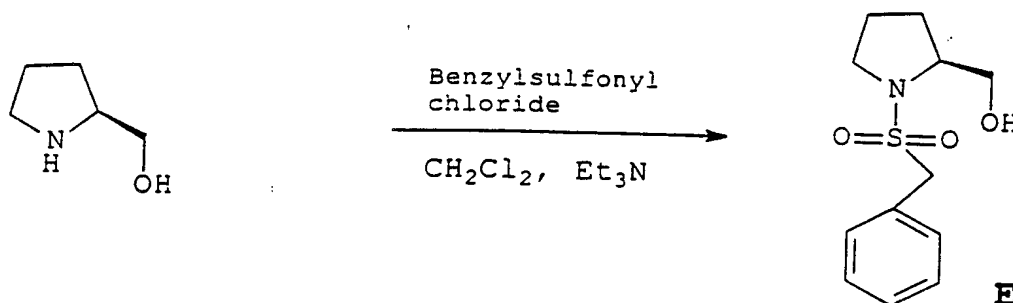
#### EXAMPLES

The inventive compounds may be prepared by a variety of synthetic sequences that utilize established chemical transformations. An exemplary general pathway to the present compounds is described in Scheme I, Scheme II, and Scheme III.

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SCHEME ISCHEME II

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SCHEME IIIEXAMPLE 1

Synthesis of (2S)-N-(benzylsulfonyl)-2-pyrrolidinecarboxylic acid (Compound 1) (A)

To a cooled (0°C) solution of proline methyl ester hydrochloride salt (5.0 g; 30.19 mmol) in 200 mL of methylene chloride was added triethylamine (35mL) and benzenesulfonyl chloride (5.75 g; 30.19 mmol). The mixture was stirred for one hour at 0°C and then washed with 2 x 100 mL of water. The organic phase was dried and concentrated. Chromatography eluting with 50% EtOAc/hexane delivered 8.14 g (5%) of the N-sulfonamide methyl ester, which was dissolved in 120 mL of methanol, cooled to 0°C, and treated with 40 mL of 1 N lithium hydroxide. The mixture was stirred for 1 hour at 0°C and then overnight at room temperature. After making the reaction mixture acidic (pH 1) with 1 N HCl, the product was extracted into methylene chloride and dried and



concentrated to yield 4.25 g of (2S)-N-(benzylsulfonyl)-2-pyrrolidinecarboxylic acid (A) as a white solid,  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 400 MHz):  $\delta$  1.85-1.90 (m, 2H); 2.08 (m, 1H); 2.18 (m, 1H); 3.04 (m, 1H); 3.27 (m, 1H); 4.32-4.35 (m, 2H); 4.45 (m, 1H); 4.45 (m, 2H); 7.36 (m, 3H); 7.48 (m, 2H); 10.98 (br, 1H).

### EXAMPLE 2

Synthesis of (2S)-1-(phenylmethylsulfonyl)-2-hydroxymethyl pyrrolidine (Compound 95) (E).

To a solution of (S)-(+)-2-pyrrolidinemethanol (1.01 g, 10 mmol) and triethylamine (1.5 ml, 11 mmol) in 30 ml methylene chloride was added 1.9 g (10 mmol)  $\alpha$ -toluenesulfonyl chloride at 0°C with stirring. The reaction was gradually warmed up to room temperature and stirred overnight. The mixture was diluted with water, and extracted into 200 ml methylene chloride. The organic extract was concentrated and further purified by silica gel to give 1.5 g product as a white solid (58.9% yield).  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  0.71-1.88 (m, 4H); 2.05 (br, 1H, OH); 3.22 (m, 2H); 3.47 (m, 2H); 3.67 (m, 1H); 4.35 (s, 2H); 7.26-7.44 (m, 5H, aromatic).

### EXAMPLE 3

Synthesis of (2S)-1-(phenylmethylsulfonyl)-2-

pyrrolidinecarboxamide (Compound 95) (B).

To a solution of L-prolinamide (2.28 g, 20 mmol) and triethylamine (5.76 ml, 42 mmol) in 40 ml methylene chloride was added 3.92 g (20 mmol)  $\alpha$ -toluenesulfonyl chloride at 0°C with stirring. The reaction was gradually warmed up to room temperature and stirred overnight. The mixture was diluted with water, and extracted into 200 ml methylene chloride. The organic extract was concentrated and further purified by silica gel to give 3.0 g product as a white solid (55.7% yield).  $^1\text{H NMR}$  ( $\text{CDCl}_3$ ):  $\delta$  01.89 (m, 3H); 2.25 (m, 1H); 3.40 (m, 1H); 3.50 (m, 1H); 3.96 (m, 1H); 4.35 (s, 2H); 7.39-7.45 (m, 5H, aromatic).

EXAMPLE 4Synthesis of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarbonitrile (Compound 97) (C).

To a solution of 0.67 ml DMF (8.7 mmol) in 10 ml acetonitrile at 0°C was added 0.70 ml (8.0 mmol) oxalyl chloride. A white precipitate was formed immediately and was accompanied by gas evolution. When complete, a solution of 2.0 g (7.5 mmol) of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarboxamide in 5.0 ml acetonitrile was added. When the mixture became homogeneous, 1.35 ml

(16.5 mmol) pyridine was added. After 5 min., the mixture was diluted with water, and extracted by 200 ml ethyl acetate. The organic layer was concentrated and further purified by silica gel to give 1.5 g product as a white solid (80% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 01.92 (m, 2H); 2.01 (m, 1H); 2.11 (m, 1H); 3.45 (m, 2H); 4.35 (s, 2H); 4.65 (m, 1H); 7.26-7.45 (m, 5H, aromatic).

#### EXAMPLE 5

Synthesis of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarbonitrile (Compound 4) (D).

A mixture of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarbonitrile (250 mg, 1 mmol), NaN<sub>3</sub> (81 mg, 1.3 mmol) and NH<sub>4</sub>Cl (70 mg, 1.3 mmol) in 3 ml DMF was stirred at 130°C for 16 hours. The mixture was concentrated and purified by silica gel to give 120 mg product as a white solid (41.1% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 01.95 (m, 2H); 2.21 (m, 1H); 2.90 (m, 1H); 3.40 (m, 2H); 4.27 (s, 2H); 5.04 (m, 1H); 7.36-7.41 (m, 5H, aromatic); 8.05 (s, 1H, NH).

Example 6Synthesis of 3-phenyl-1-propyl (2S)-1-(3,3-dimethyl-1,2-dioxopentyl)-2-pyrrolidinecarboxylate (1)Methyl (2S)-1-(1,2-dioxo-2-methoxyethyl)-2-pyrrolidinecarboxylate

A solution of L-proline methyl ester hydrochloride (3.08 g; 18.60 mmol) in dry methylene chloride was cooled to 0°C and treated with triethylamine (3.92 g; 38.74 mmol; 2.1 eq). After stirring the formed slurry under a nitrogen atmosphere for 15 min, a solution of methyl oxalyl chloride (3.20 g; 26.12 mmol) in methylene chloride (45 ml) was added dropwise. The resulting mixture was stirred at 0°C for 1.5 hour. After filtering to remove solids, the organic phase was washed with water, dried over MgSO<sub>4</sub> and concentrated. The crude residue was purified on a silica gel column, eluting with 50% ethyl acetate in hexane, to obtain 3.52 g (88%) of the product as a reddish oil. Mixture of cis-trans amide rotamers; data for trans rotamer given. <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 1.93 (dm, 2H); 2.17 (m, 2H); 3.62 (m, 2H); 3.71 (s, 3H); 3.79, 3.84 (s, 3H total); 4.86 (dd, 1H, J = 8.4, 3.3).  
Methyl (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidinecarboxylate

A solution of methyl (2S)-1-(1,2-dioxo-2-methoxyethyl)-2-pyrrolidinecarboxylate (2.35 g; 10.90 mmol) in 30 ml of tetrahydrofuran (THF) was cooled to -78°C and treated with 14.2 ml of a 1.0 M solution of 1,1-dimethylpropylmagnesium chloride in THF. After

stirring the resulting homogeneous mixture at  $-78^{\circ}\text{C}$  for three hours, the mixture was poured into saturated ammonium chloride (100 ml) and extracted into ethyl acetate. The organic phase was washed with water, 5 dried, and concentrated, and the crude material obtained upon removal of the solvent was purified on a silica gel column, eluting with 25% ethyl acetate in hexane, to obtain 2.10 g (75%) of the oxamate as a colorless oil.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ): d 0.88 (t, 3H); 1.22, 10 1.26 (s, 3H each); 1.75 (dm, 2H); 1.87-2.10 (m, 3H); 2.23 (m, 1H); 3.54 (m, 2H); 3.76 (s, 3H); 4.52 (dm, 1H,  $J = 8.4, 3.4$ ).

Synthesis of (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidinecarboxylic acid

15 A mixture of methyl (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidinecarboxylate (2.10 g; 8.23 mmol), 1 N LiOH (15 ml), and methanol (50 ml) was stirred at  $0^{\circ}\text{C}$  for 30 minutes and at room temperature overnight. The mixture was acidified to pH 1 with 1 N 20 HCl, diluted with water, and extracted into 100 ml of methylene chloride. The organic extract was washed with brine and concentrated to deliver 1.73 g (87%) of snow-white solid which did not require further purification.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ): d 0.87 (t, 3H); 1.22, 25 1.25 (s, 3H each); 1.77 (dm, 2H); 2.02 (m, 2H); 2.17 (m, 1H); 2.25 (m, 1H); 3.53 (dd, 2H,  $J = 10.4, 7.3$ ); 4.55 (dd, 1H,  $J = 8.6, 4.1$ ).

3-Phenyl-1-propyl (2S)-1-(3,3-dimethyl-1,2-dioxopentyl)-2-pyrrolidinecarboxylate (1)

A mixture of (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidine-carboxylic acid (600 mg; 2.49 mmol), 3-phenyl-1-propanol (508 mg; 3.73 mmol),  
5 dicyclohexylcarbodiimide (822 mg; 3.98 mmol), camphorsulfonic acid (190 mg; 0.8 mmol) and 4-dimethylaminopyridine (100 mg; 0.8 mmol) in methylene chloride (20 ml) was stirred overnight under a  
10 nitrogen atmosphere. The reaction mixture was filtered through Celite to remove solids and concentrated in vacuo, and the crude material was purified on a flash column (25% ethyl acetate in hexane) to obtain 720 mg (80%) of Example 1 as a  
15 colorless oil. <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 0.84 (t, 3H); 1.19 (s, 3H); 1.23 (s, 3H); 1.70 (dm, 2H); 1.98 (m, 5H); 2.22 (m, 1H); 2.64 (m, 2H); 3.47 (m, 2H); 4.14 (m, 2H); 4.51 (d, 1H); 7.16 (m, 3H); 7.26 (m, 2H).

Figure 1. GPI 1046 protects retinal ganglion cells against degeneration following retinal ischemia.

Retinal ganglion cells were retrogradely labeled in adult rats by bilateral injection of fluorogold in their lateral geniculate nuclei. Labeled ganglion cells in the normal rat retina appear as white profiles against the dark background (Figure 1A). Complete retinal ischemia was produced by infusing normal saline solution into the retinal vitreous cavity of each eye until the intraocular pressure exceeded arterial blood pressure. 28 days after the ischemic episode extensive degeneration of retinal ganglion cell was evidenced by massive reduction in the density of fluorogold labeled cells (Figure 1B). Administration of GPI 1046 (10mg/kg, s.c.) 1 hour prior to the ischemic episode and at 10mg/kg/day for the next four days produced noticeable protection of a large proportion of the vulnerable ganglion cell population (Figure 1C).

Figure 2. GPI 1046 prevents degeneration of optic nerve axons and myelin following retinal ischemia

Examination of the optic nerves from the same retinal ischemia cases reveals that GPI 1046 produces dramatic protection of optic nerve element from ischemic degeneration. Toluidine blue staining of epon embedded optic nerve cross sections revealed the detail of myelin sheaths (white circles) and optic nerve axons

(black centers) in the normal rat optic nerve. Optic nerves from vehicle treated cases examined 28 days after a 1 hour retinal ischemic episode are characterized by a decreased density of optic nerve axons and the appearance of numerous degenerating myelin figures (bright white filled circles). Treatment with GPI 1046 protected the majority of optic nerve axons from degeneration and also dramatically decreased the density of degenerating myelin figures.

Figure 3. GPI 1046 provides moderate protection against retinal ganglion cell death after optic nerve transection

Complete transection of the optic nerve 5 mm from the eyeball produces massive degeneration of retinal ganglion cells, representing loss of >87% of the normal ganglion cell population 90 days after the injury (Table 1). Few spared fluorogold pre labeled ganglion cells are present in vehicle treated cases (large white figures) among a population of small microglia that digest the debris of the degenerating cells and take up the fluorogold label (Figure 3A). Treatment with GPI 1046 for 14 days resulted in a small but not significant increase in the density of retinal ganglion cells that survived 90 days after transection (Table 1) but treatment with GPI 1046 for the first 28 days after transection produced moderate but significant



protection of 12.6% of the vulnerable ganglion cell population (Table 1, Figure 3B).

Figure 4. GPI 1046 treatment duration significantly affects the process of optic nerve axonal degeneration after transection.

Examination of optic nerve axon density in the proximal stump of the optic nerve from the same cases revealed a more dramatic protection afforded by GPI 1046

treatment. 90 days after transection few ganglion cell axons remain within the optic nerve (Figure 4B), representing only 5.6% of the normal population. The

loss of axons reflects both the death of retinal

ganglion cells and the regression or "dying back" of

the axons of ~ 70% of the small surviving ganglion cell population into the retina itself (Table 1). Treatment

with GPI 1046 for the first 14 days after optic nerve transection produced a small but significant 5.3%

protection of optic nerve axons (Figure 4D, Table 1),

but treatment with the same dose of GPI 1046 for 28

days resulted in the protection of optic nerve axons

for the vast majority (81.4%) of spared retinal

ganglion cells (Figure 4C, Table 1).

Figure 5. GPI 1046 treatment produces a greater effect on optic nerve axons than ganglion cell bodies

This summary figure shows data from Figure 3 ganglion cell protection and higher power photomicrographs of

optic nerve axon protection (Figure 5A&B, upper panels). 28 day treatment with GPI 1046 produced a significant increase in the density of large, and particularly medium and small caliber optic nerve axons (Figure 5C&D, lower panels).

Figure 6. GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the proximal stump

Myelin basic protein immunohistochemistry labels fascicles (darker labeled 'islands') of myelinated axons in the normal optic nerve (Figure 6A, upper left). 90 days after transection extensive degeneration of myelin is evident in vehicle treated cases, characterized by the loss of fascicular organization and the appearance of numerous large dense degenerating myelin figures (Figure 6B, upper right). Treatment with GPI 1046 for the first 14 days after optic nerve transection did not alter the pattern of myelin degeneration (Figure 6C, lower left panel), and yielded an insignificant 1.6% quantitative recovery in myelin density (Table 1). Extending the GPI 1046 treatment course through the first 28 days after optic nerve transection produced a dramatic preservation of the fascicular staining pattern for myelin basic protein in the proximal stump of the optic nerve and decreased the density of degenerating myelin figures

(Figure 6D, lower right panel), representing a '70% recovery of myelin density (Table 1).

Figure 7. FKBP-12 immunohistochemistry labels

5 oligodendroglia (large dark cells with fibrous processes), the cells which produce myelin, located between the fascicles of optic nerve fibers, and also some optic nerve axons.

10 Figure 8. GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the distal stump.

Complete transection of the optic nerve leads to degeneration of the distal segments (axon fragments disconnected from the ganglion cell bodies), and the  
15 degeneration of their myelin sheaths. 90 days after transection (Figure 8B) myelin basic protein immunohistochemistry reveals the near total loss of fascicular organization (present in the normal optic  
20 nerve, Figure 8A) and the presence of numerous dense degenerating myelin figures. Quantitation reveals that the cross sectional area of the transected distal stump shrinks by 31% and loses approximately 1/2 of its myelin (Table 1). Treatment with GPI 1046 for the  
25 first 14 days after transection did not protect against shrinkage of the distal stump but did slightly increase the density of myelin, though the density of

degenerating myelin figures remained high (Figure 8C, Table 1). GPI 1046 treatment through the first 28 days produced dramatic protection of the fascicular pattern of myelin labeling, decreased the density of  
5 degenerating myelin figures, prevented cross sectional shrinkage of the distal stump of the transected nerve and maintained the myelin levels at ~99% of normal levels (Figure 8D, Table 1).

10 Figure 9. 28 day treatment with GPI 1046 treatment beginning 8 weeks after onset of streptozotocin induced diabetes decreases the extent of neovascularization in the inner and outer retina and protects neurons in the inner nuclear layer (INL) and ganglion cell layer (GCL)  
15 from degeneration.

Negative images of cresyl violet stained tangential retinal sections reveals perikarya in the three cellular layers (Figure 9A). The retinae of streptozotocin treated animals administered only  
20 vehicle (Figure 9B) exhibited loss of cells from the ONL and INL, decreased thickness of the Outer plexiform layer (the dark area between ONL and INL) and a dramatic increase in the size and density of retinal blood vessels (large black circular outlines) in the  
25 INL, OPL, ONL and the photoreceptor layer (PR, the gray fuzzy area above the ONL). GPI 1046 treatment reduced neovascularization (i.e. prevented the proliferation of

blood vessels) in the PR, ONL, OPL and INL. Although  
GPI 1046 did not appear to protect against neuronal  
loss in the ONL, it appeared to decrease the loss of  
neurons in both the INL and GCL compared to  
5 streptozotocin/vehicle treated controls.

Example 7

10                   In Vivo Retinal Ganglion Cell  
                    and Optic Nerve Axon Tests

          The extent of degeneration reduction or prevention in retinal ganglion cells and optic nerve axons was determined in a vision loss model utilizing surgical optic nerve transection to simulate mechanical damage to the optic nerve. The effects of several neuroimmunophilin FKBP ligands on retinal ganglion cells neuroprotection and optic nerve axon density was determined experimentally, comparing 14 day and 28 day neuroimmunophilin FKBP ligand treatments. The effects of treatment with neuroimmunophilin FKBP ligands on retinal ganglion cells and optic nerve axons was correlated.

Surgical Procedures

25           Adult male Sprague Dawley rats (3 months old, 225-250 grams) were anesthetized with a ketamine

(87mg/kg) and xylazine (13mg/kg) mixture. Retinal ganglion cells were pre-labeled by bilateral stereotaxic injection of the fluorescent retrogradely transported marker fluoro-gold (FG, 0.5 microliters of 2.5% solution in saline) at the coordinates of the LGNd (4.5 millimeters post  $\beta$ , 3.5 millimeters lateral, 4.6 millimeters below dura). Four days later, FG labeled rats underwent a second surgery for microsurgical bilateral intraorbital optic nerve transection 4-5 millimeters behind the orbit.

Experimental animals were divided into six experimental groups of six rats (12 eyes) per group. One group received a neuroimmunophilin FKBP ligand (10 milligrams per kg per day sc in PEG vehicle (20 percent propylene glycol, 20 percent ethanol, and 60 percent saline)) for 14 days. A second group received the same neuroimmunophilin FKBP ligand dose for 28 days. Each treated group had a corresponding sham/surgery and transection control group which received corresponding 14 or 28 day dosing with the vehicle only.

All animals were sacrificed 90 days after optic nerve transection and perfused pericardially with formalin. All eyes and optic nerves stumps were removed. Cases were excluded from the study if the optic nerve vasculature was damaged or if FG labeling

was absent in the retina.

#### Retinal Ganglion Cell Counts

Retinas were removed from eyes and prepared for wholemount analysis. For each group, five eyes with  
5 dense and intense FG labeling were selected for quantitative analysis using a 20 power objective. Digital images were obtained from five fields in the central retina (3-4 millimeters radial to optic nerve head). FG labeled Large ( $>18 \mu\text{m}$ ), medium ( $12-16 \mu\text{m}$ ),  
10 and small ( $<10 \mu\text{m}$ ) ganglion cells and microglia were counted in five  $400 \mu\text{m}$  by  $400 \mu\text{m}$  fields per case, 5 cases per group.

#### Examination of Optic Nerves

Proximal and distal optic nerve stumps were  
15 identified, measured, and transferred to 30% sucrose saline. The proximal stumps of five nerves were blocked and affixed to a chuck, and 10 micron cross sections were cut on a cryostat; one in ten sections were saved per set. Sections including the region 1-2  
20 mm behind the orbit were reacted for RT97 neurofilament immunohistochemistry. Analysis of optic nerve axon density was performed using a 63 power oil immersion lens, a Dage 81 camera, and the Simple Image Analysis program. RT97 positive optic nerve axons  
25 were counted in three  $200 \mu\text{m}$  by  $200 \mu\text{m}$  fields per nerve. The area of the nerve was also determined for



each case at 10 power.

As depicted graphically in Table I&II, the 14 day course of treatment with a neuroimmunophilin FKBP ligand provided moderate neuroprotection of retinal ganglion cells observed 28 days after optic nerve transection. However, by 90 days after transection, only 5% of the ganglion cell population remained viable.

90 days after optic nerve transection the number of axons persisting in the proximal stump of the optic nerve represented approximately one half of the number of surviving ganglion cells in groups of animals that received vehicle alone or the 14 day course of treatment with a neuroimmunophilin FKBP ligand. These results indicate that over half of the transected ganglion cell axons retract beyond the optic nerve head, and that treatment with a neuroimmunophilin FKBP ligand during the first 14 days after optic nerve transection is not sufficient to arrest this retraction.

As depicted graphically in Table I&II, more prolonged treatment with a neuroimmunophilin FKBP ligand during the 28 day course of treatment produced a moderate increase in retinal ganglion cell neuroprotection. Approximately 12% of the vulnerable retinal ganglion cell population was protected. A

Table 1.  
Effect of prolonged GPT 1046 treatment on retinal ganglion cell survival,  
optic nerve axon preservation, and myelination 90 days after optic nerve transection

| GROUP                | RGC Counts <sup>1</sup> | ON Axon density <sup>2</sup> | ON head area (%sham) | % RGC's Rescued | increased ON axon density <sup>3</sup> | Spared RGC population | ON axon Count <sup>4</sup> | % surviving RGC's with ON axons | Proximal optic nerve myelin basic protein Density <sup>5</sup> | Distal optic nerve myelin basic protein Density <sup>5</sup> |
|----------------------|-------------------------|------------------------------|----------------------|-----------------|--|-----------------------|----------------------------|---------------------------------|--|--|
| Sham                 | 290 ± 14.8              | 7600*                        | 100%                 | -               | -                                      | 120,000*              | 120,000                    | 100%                            | normal   | -  |
| ONT/Vehicle          | 35.9 ± 2.8              | 428 ± 34                     | 68%                  | (87% loss)      | -                                      | 14,855 *              | 4593                       | 30.9%                           | 52 ± 5.2 SEM % loss  | 31% shrinkage 52 % loss                                      |
| ONT/14 days GPT 1046 | 49 ± 5.3                | 569 ± 23                     | 76%                  | 5.3%            | 1.5X                                   | 20,275                | 6820                       | 33.6%                           | 1.6 ± 3.0 SEM % recovery                                       | 31% shrinkage 47% loss                                       |
| ONT/28 days GPT 1046 | 67.9 ± 5.8*             | 1526 ± 120*                  | 95%*                 | 12.6%*          | 5.0X                                   | 28,096*               | 22,861*                    | 81.4%                           | 70 ± 6.3 SEM % recovery*                                       | 36% less shrinkage* 99% myelin preservation*                 |

\*Significance p < .001

<sup>1</sup> Mean density ± SEM of Fluoro gold labeled retinal ganglion cells (RGC) in 400 µm x 400 µm sample gridfields.

<sup>2</sup> mean density ± SEM of RT97 neurofilament antibody labeled optic nerve (ON) axons in 200 µm x 200µm region of interest

<sup>3</sup> estimate for 200 µm x 200µm region in normal optic nerve assuming 120,000 RGC axons in normal rat optic nerve, measured to be 0.630 mm<sup>2</sup> mean cross sectional area

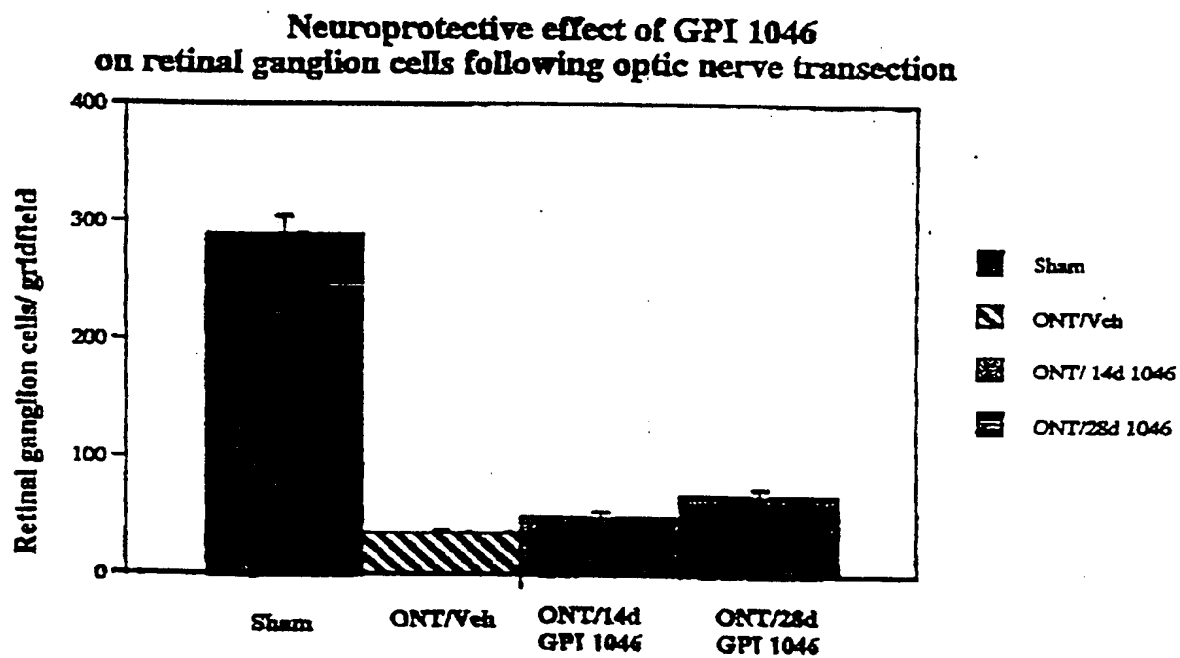
<sup>4</sup> adjusted for optic nerve diameter

<sup>5</sup> calculated by multiplying axonal density by ON area

<sup>6</sup> determined from 20X analysis of % areal coverage of optic nerve cross section

<sup>7</sup> shrinkage determined by comparing cross sectional area to sham control, myelin levels determined by multiplying cross sectional area by myelin density

TABLE II



similar proportion (~50%) of optic nerve axon density sparing was also observed. These results demonstrate the startling result that extending the duration of treatment with a neuroimmunophilin FKBP ligands to 28 days after transection completely arrests the regression of damaged axons for essentially the entire surviving population of retinal ganglion cells.

Additional results are set forth in Tables III & IV.

TABLE III

Correlation between Retinal Ganglion Cell and Optic Nerve Axon Sparing at 90 days following optic nerve transection and 14 or 28 day GPI 1046 treatment

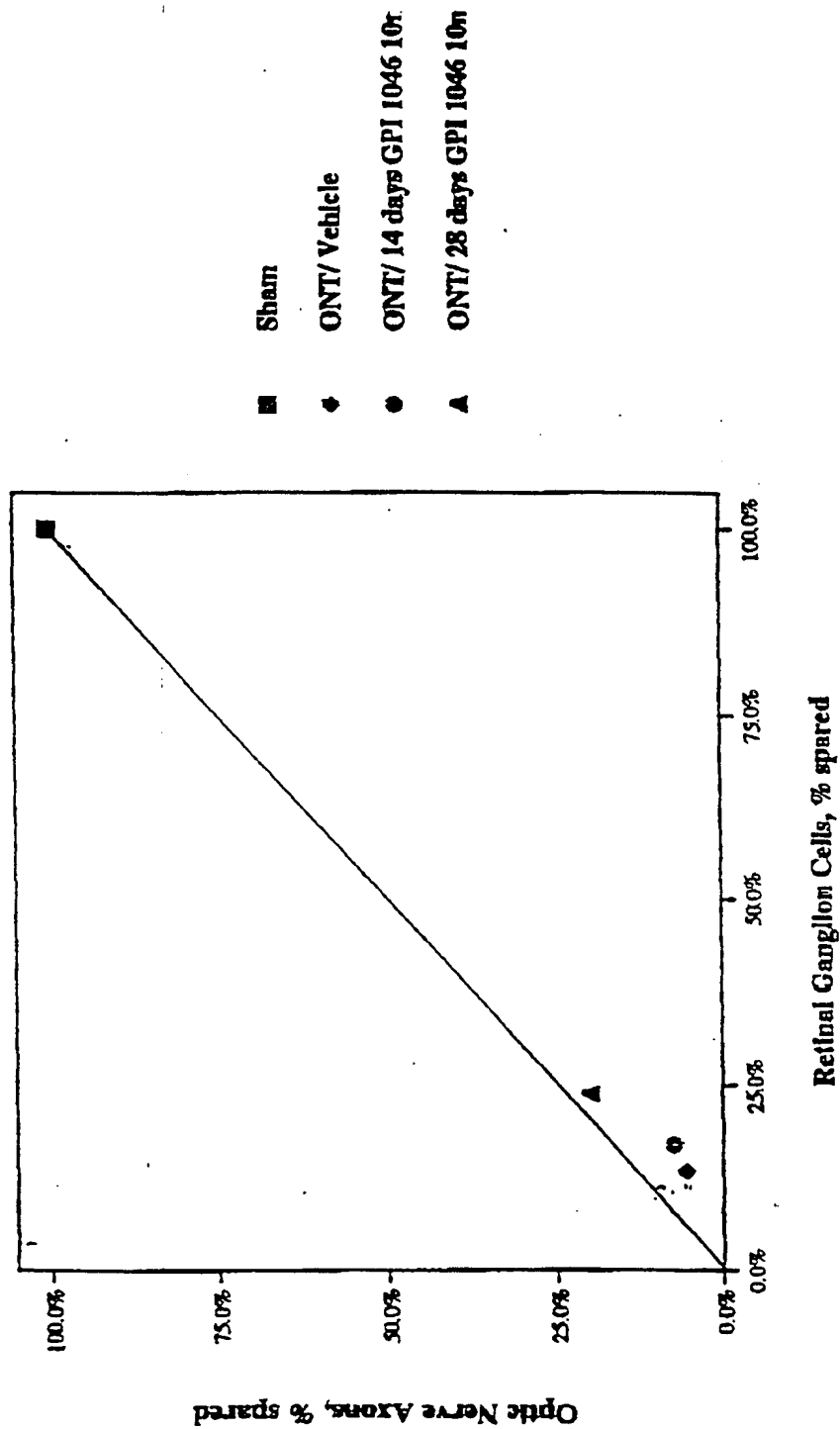
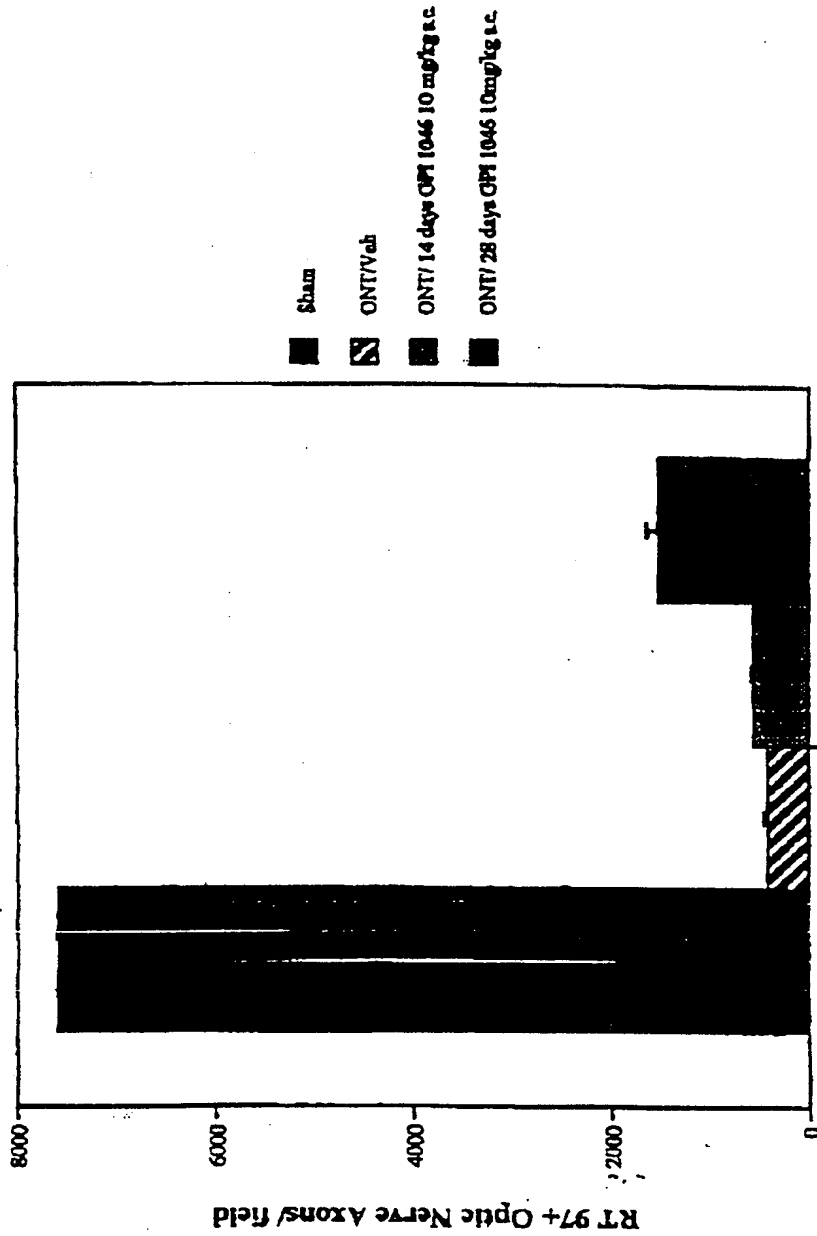


TABLE IV

GPI 1046 preserves optic nerve axons  
in the proximal stump following transection



Row Number

Example 8

A patient is suffering from macular degeneration.  
A derivative as identified above, alone or  
in combination with one or more other neoplastic factors,  
5 or a pharmaceutical composition comprising the same,  
may be administered to the patient. A reduction in  
vision loss, prevention of vision degeneration, and/or  
promotion of vision regeneration are/is expected to  
occur following treatment.

10

Example 9

A patient is suffering from glaucoma, resulting  
in cupping of the optic nerve disc and damage to nerve  
fibers. A derivative as identified above,  
15 alone or in combination with one or more other neoplastic  
factors, or a pharmaceutical composition comprising  
the same, may be administered to the patient. A  
reduction in vision loss, prevention of vision  
degeneration, and/or promotion of vision regeneration  
20 are/is expected to occur following treatment.

Example 10

A patient is suffering from cataracts requiring  
surgery. Following surgery, a derivative  
25 as identified above, alone or in combination with one  
or more other neoplastic factors, or a pharmaceutical

composition comprising the same, may be administered  
to the patient. A reduction in vision loss,  
prevention of vision degeneration, and/or promotion of  
vision regeneration are/is expected to occur following  
5 treatment.

#### Example 11

A patient is suffering from an impairment or  
blockage of retinal blood supply relating to diabetic  
10 retinopathy, ischemic optic neuropathy, or retinal  
artery or vein blockage. A derivative as  
identified above, alone or in combination with one or  
more other neoplastic factors, or a pharmaceutical  
composition comprising the same, may be administered  
15 to the patient. A reduction in vision loss,  
prevention of vision degeneration, and/or promotion of  
vision regeneration are/is expected to occur following  
treatment.

#### Example 12

20 A patient is suffering from a detached retina.  
A derivative as identified above, alone or  
in combination with one or more other neoplastic factors,  
or a pharmaceutical composition comprising the same,  
25 may be administered to the patient. A reduction in  
vision loss, prevention of vision degeneration, and/or



promotion of vision regeneration are/is expected to occur following treatment.

Example 13

5           A patient is suffering from tissue damage caused by inflammation associated with uveitis or conjunctivitis. A           derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

Example 14

15           A patient is suffering from photoreceptor damage caused by chronic or acute exposure to ultraviolet light. A           derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

Example 15

A patient is suffering from optic neuritis. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

Example 16

A patient is suffering from tissue damage associated with a "dry eye" disorder. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

**Example 17**

**Efficacy of representative compounds from different immunophilin ligand series in protecting retinal ganglion cell axons from degeneration following optic nerve transection is set forth in Table V.**

**Efficacy of representative compounds from  
different immunophilin ligand series  
in protecting retinal ganglion cell axons from  
degeneration following optic nerve transection**

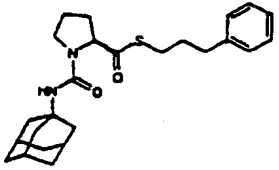
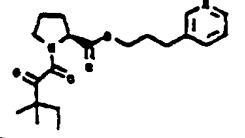
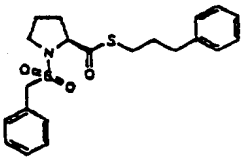
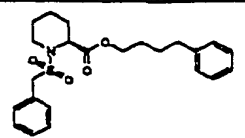
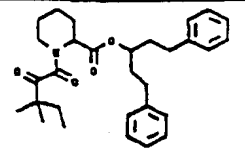
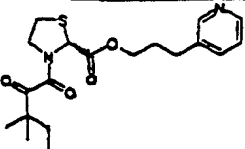
| Compound      | Structure   | Comments  | K <sub>i</sub> for RGC axon density<br>loss after ON transection<br>(6-8 ON axons/axon) |
|---------------|---|---|---|
| B             |    | Adamantyl<br>Thioester of urea<br>K <sub>i</sub> rotomase = 149 nM<br>Clearance = 7 µl/min            | 100.0 %<br>±5.2 % SEM   |
| A<br>GPI 1046 |    | Ester<br>K <sub>i</sub> rotomase = 7.5 nM<br>Clearance = 63.8 µl/min                                  | 60.5 %<br>±3.9 % SEM  |
| C             |    | Sulfonamide<br>K <sub>i</sub> rotomase = 107 nM<br>Clearance = 31.1 µl/min                            | 60.4 %<br>±3.1 % SEM  |
| D             |   | Piperidic sulfonamide<br>K <sub>i</sub> rotomase = nM<br>Clearance = µl/min                           | 58.4 %<br>±6.4 % SEM  |
| E             |  | Ester of pipecolic acid<br>K <sub>i</sub> rotomase = 20 nM<br>Clearance = 41.8 µl/ml                  | 56.6 %<br>±9.4 % SEM  |
| F             |  | Proline heterocycle<br>Analog of GPI 1046<br>K <sub>i</sub> rotomase = 272 nM<br>Clearance = ? µl/min | 55.1 %<br>±5.9 % SEM  |

TABLE V

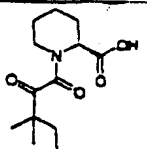
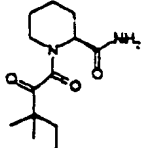
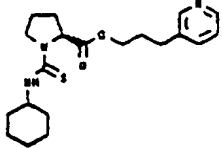
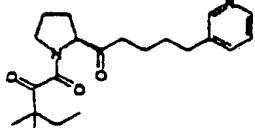
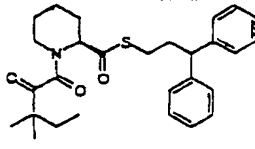
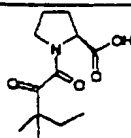
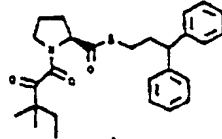
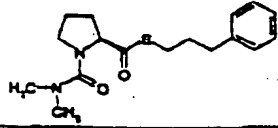
|   |   |   |                          |
|---|---|---|--------------------------|
| G |    | Pipercolic acid<br>dimethyl ketone<br>Ki rotomase >10,000 nM<br>Clearance=? $\mu\text{l/min}$ | 34.0%<br>$\pm 4.8\%$ SEM |
| H |    | Ki rotomase = nM<br>Clearance=? $\mu\text{l/min}$   | 30.3%<br>$\pm 8.0\%$ SEM |
| I |    | Ester of Thiourea<br>Ki rotomase= 131 nM<br>Clearance=8.0 $\mu\text{l/min}$                   | 23.8%<br>$\pm 5.3$ SEM   |
| J |    | Ketone -<br>analog of GPI 1046<br>Ki rotomase= 210nM<br>Clearance=1.5 $\mu\text{l/min}$       | 15.8%<br>$\pm 4.8\%$ SEM |
| K |   | Pipercolic acid Thioester<br>Ki rotomase= 86nM<br>Clearance= 4.5 $\mu\text{l/min}$            | 13.0%<br>$\pm 4.2\%$ SEM |
| L |  | Prolyl acid<br>Ki rotomase= >7743nM<br>Clearance=5.2 $\mu\text{l/min}$                        | 7.8%<br>$\pm 3.0\%$ SEM  |
| M |  | Thioester<br>Ki rotomase =7nM<br>Clearance=12.5 $\mu\text{l/min}$                             | -6.3%<br>$+3.9\%$ SEM    |
| N |  | Ki rotomase = 722 nM<br>Clearance= 21.9 $\mu\text{l/min}$                                     |                          |

TABLE V continued

Example 18

5           THE FKBP NEUROIMMUNOPHILIN LIGAND GPI-1046  
          ENHANCES RETINAL GANGLION CELL SURVIVAL  
          AND ARRESTS AXONAL DYING BACK  
          FOLLOWING OPTIC NERVE TRANSECTION

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          Transection of the mammalian optic nerve results  
          in a brief period of abortive regeneration, but the  
          majority of axotomized neurons die and the axons from  
          many persisting ganglion cells die back beyond the  
15          optic nerve head. The present Example was designed to  
          examine the neuroprotective effects of GPI-1046  
          following optic nerve transection.

          Retinal ganglion cells in adult male Sprague  
20          Dawley rats were retrogradely labeled by fluorogold  
          injection in the LGNd and four days later the optic  
          nerves were transected 5 mm behind the globe. Groups  
          of animals received either GPI-1046 10mg/kg/day s.c. or  
          vehicle for 28 days. All experimental animals and  
25          controls were sacrificed 90 days after transection.

          By 90 days only - 10% of the FG labeled ganglion  
          cell population survived but less than half of these  
          neurons maintained axons that extended past the optic  
30          nerve head, as detected with RT97 neurofilament  
          immunohistochemistry. GPI-1046 treatment produced a  
          moderate degree of perikaryal neuroprotection, sparing

25% of the ganglion cell population, and preserved the axons of virtually all protected neurons in the proximal stump of the transected nerve. These results indicate that treatment with the FKBP neuroimmunophilin ligand GPI-1046 produces a fundamental alteration in the pathological process following injury to CNS tracts.

These results also demonstrate that the small molecule FKBP neuroimmunophilin ligand GPI 1046 enhances neurite outgrowth in culture, enhance peripheral nerve regeneration, and stimulate sprouting within the CNS following partial deafferentation.

Example 19

5           NEUROIMMUNOPHILIN LIGANDS PROMOTE RECOVERY  
FROM THE PERIPHERAL SENSORY NEUROPATHY ASSOCIATED  
WITH STREPTOZOTOCIN-INDUCED DIABETES

10           Peripheral neuropathy is a common debilitating  
complication of Type 2 diabetes in some 30-40% of  
diabetic patients. Neurotrophic factors such as nerve  
growth factor (NGF) are known to promote survival of  
developing and adult neurons of the peripheral nervous  
15          system (PNS), and have also been evaluated as  
treatments for diabetic peripheral neuropathy. Some of  
the selective ligands of the neuroimmunophilin FKBP-12  
such as the small molecule GPI-1046, have also been  
shown to promote repair and regeneration in the central  
20          and peripheral nervous systems (Proc. Nat'l. Acad. Sci.  
USA 94, 2019-2024, 1997).

          In this Example the potential therapeutic effects  
of GPI-1046 were evaluated for its ability to improve  
25          sensory function in the streptozotocin-induced diabetic  
rat. The procedure involved using Male Wistar rats  
which were given a single injection of streptozotocin  
(65 mg/kg i.v.). Blood glucose levels were determined  
weekly for the first three weeks and on the last week  
30          of the experiment. Animals were evaluated weekly for  
signs of sensory neuropathy using the conventional hot  
plate and tail flick apparatus test procedures. After



six weeks, treatment either with GPI-1046 or vehicle was initiated.

The results demonstrated that behavioral testing using the hot plate and the tail flick apparatus indicated improvement in latency in lesioned animals treated for 6 weeks with GPI-1046 at 10 mg/kg s.c. The results also showed that GPI-1046 ameliorates the behavioral sequelae of diabetic sensory neuropathy and may offer some relief for patients suffering from diabetic peripheral neuropathy.

Morris Watermaze/Aging and Memory Test Procedure

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Aged rodents exhibit marked individual differences in performance on a variety of behavioral tasks, including two-choice spatial discrimination in a modified T-maze, spatial discrimination in a circular platform task, 10 passive avoidance, radial maze tasks, and spatial navigation in a water pool.

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In all of these tasks, a proportion of aged rats or mice perform as well as the vast majority of young control animals, while other animals display severe impairments in memory function compared to young animals. For example, Fischer and colleagues showed that the proportion of rats displaying significant impairments in spatial navigation increases with age, (Fischer et al. 20 1991b) with 8% of all 12 month old, 45% of 18 month old, 53% of 24 month old, and 90% of all 30 month old rats displaying impairments in spatial acquisition of the Morris watermaze task relative to young controls.

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Specifically, rodent spatial learning and memory decline during aging has been accepted by many investigators as an intriguing correlative animal model of human senile dementia. Cholinergic function in the hippocampus has

been extensively studied as a component of spatial learning in rodents, and declining hippocampal cholinergic function has been noted in parallel with the development of learning and memory impairments. In addition, other neurotransmitter systems have been shown to contribute to spatial learning, and to decline with age, such as the dopaminergic and noradrenergic, serotonergic, and glutamatergic systems.

Also, reports on age-related deficits of hippocampal long-term potentiation (LTP)-induction, a reduction in theta rhythm frequency, a loss of experience-dependent plasticity of hippocampal place-units, and reductions in hippocampal protein kinase C are in keeping with the concept that no single underlying pathology can be identified as the cause of age-related behavioral impairment in rodents. However, the various experimental therapeutic approaches that have been undertaken to improve memory function in aged rodents have been somewhat slanted towards the cholinergic hypothesis.

The Morris watermaze is widely used for assessing spatial memory formation and retention in experimental animals. The test depends on the animal's ability to utilize spatial visual information in order to locate a submerged escape platform in a water tank. It is important that the tank itself be as devoid of specific visual features

as possible - thus, it is always circular in shape, the sides are kept smooth and in uniform dull colors, and the water is rendered opaque with nontoxic watercolour pigment or powdered milk. This is to ensure that the animal navigates only by the use of more distant visual cues, or by the use of intra-maze cues specifically provided by the experimenter.

The tank is filled to a level which forces the animal to swim actively. Normal mice and rats react aversively to the swimming part of the test and will climb onto, and remain on, an escape platform from which they are removed to a heated resting cage.

If the platform is visible (i.e. above the surface), animals placed in the tank will quickly learn to home in on the platform and climb out onto it. Testing with a visible platform will also ensure that the experimental animals are not blind and show sufficient motivation and stamina to perform the task, which can be important in experiments involving aged rodents. If the platform is invisible (i.e. submerged just below the surface), normal animals learn to use distant visual cues in the test room for orientation in the test tank, and, when placed in the tank, will quickly home in on the approximate location of the platform and circle in that area until the platform is found.

The animals' path, speed, and swim time are tracked with a ceiling camera for later computerized analysis. Over the course of several successive trials, spatial learning can therefore be defined as a drop of distance swum, or time elapsed, from placement in the tank until escape onto the invisible platform.

The test can be adapted to assess several aspects of spatial memory: a) acquisition of a cued task, where the animal's ability to link one visual cue directly with the escape platform depends on cortical function (i.e. a ball is suspended over the escape platform and the animal learns to follow this cue to find the platform); b) acquisition of a spatial task, where the animal's ability to learn the location of a submerged escape platform based on a combination of distant visual cues is dependent upon hippocampal function (i.e. the animal learns to triangulate its position in the tank by visually aligning the paper-tower dispenser with the door and ceiling lamp); c) retention of a successfully acquired spatial task, which is predominantly dependant on cortical function (i.e. the animal must remember the spatial location of the platform over several weeks); d) a hippocampus-dependant reversal task where the animals must reacquire a new spatial platform location (i.e. the platform is moved to a new location between swim trials

and the animal must abandon its previous search strategy and acquire a new one).

5 These different modifications of the Morris watermaze procedure can be applied in sequence to the same set of experimental animals and allow for a thorough characterization of their spatial memory performance and its decline with normal ageing. Moreover, such a series of sequential memory tests sheds some light on the functional integrity of the specific brain systems involved in the acquisition and retention of spatial memory (e.g. rats with cholinergic lesions of the hippocampus may remember a platform location acquired weeks before, but persevere over the old platform location after the platform is moved).

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#### Example 20

#### EFFECTS OF CHRONIC GPI-1046 ADMINISTRATION 20 ON SPATIAL LEARNING AND MEMORY IN AGED RODENTS

This Example shows the effects of chronic treatment with the systemically available FKBP-ligand GPI-1046 on spatial learning and memory in aged rodents.

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The procedure involved using three-month old (young) and 18-19 month old male C57BL/6N-Nia (aged) mice which

habituated to the well known and conventional Morris watermaze during a 4 trials/day, 3-4 day visible platform training phase. Subsequent spatial acquisition testing was conducting as follows: All mice were given 4 trials/day (block), for 5 days. Maximum swim time was 90 seconds. Aged mice were allocated to an "aged impaired" group if their performance during blocks 4 or 5 of the acquisition phase was  $>1$  S.D. above the mean of "young" mice, and to an "aged non-impaired" group if their performance was  $< 0.5$  S.D. above the mean of "young" mice. Aged groups were then split into statistically similar "GPI-1046" and "vehicle" groups.

Daily treatment with 10mg/kg GPI-1046 was initiated 3 days after the end of acquisition training, and continued through retention testing. Retention testing began after 3 weeks of dosing using the same methods as the acquisition phase. Swim Distances (cm) were analyzed in a 7 X 5 ANOVA including Groups and Blocks (1-5) as factors in the analysis, treating Blocks as a repeated measure.

The results showed that planned contrasts revealed that there were significant differences between the "young", and "aged impaired-vehicle and GPI-1046" treated groups at the end of the acquisition phase,  $F_{1,58} = 26.75$ ,  $P=0.0001$ , and  $F_{1,58} = 17.70$ ,  $P=0.0001$  respectively. While

there were no significant differences between the two "aged impaired" groups,  $F_{1,58} = 0.67$ ,  $P = 0.42$ . During retention testing, however, "aged impaired-vehicle" treated animals performed significantly poorer than "aged impaired - GPI-1046", and "young" animals,  $F_{1,59} = 8.11$ ,  $P = 0.006$ , and  $F_{1,59} = 25.45$ ,  $P = 0.0001$  respectively. There was no longer any statistically significant difference between the "young" and "aged impaired" - GPI-1046" treated groups during the retention phase,  $F_{1,59} = 3.09$ ,  $P = 0.08$ . In summary, systemic treatment with GPI-1046 significantly enhanced spatial memory performance of mice with age-related spatial memory impairments.



The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention and all such  
5 modification are intended to be included within the scope of the following claims.

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What is claimed is:

1. A method for treating a vision disorder,  
5 improving vision, treating memory impairment or enhancing  
memory performance in an animal, which comprises  
administering to said animal an effective amount of a N-  
linked sulfonamide of an N-heterocyclic carboxylic acid  
or isostere thereof.

10 2. The method of claim 1, wherein the N-linked  
sulfonamide of an N-heterocyclic carboxylic acid or  
isostere thereof is immunosuppressive or non-  
immunosuppressive.

15 3. The method of claim 1, wherein the N-linked  
sulfonamide of an N-heterocyclic carboxylic acid or  
isostere thereof has an affinity for an FKBP-type  
immunophilin.

20 4. The method of claim 3, wherein the FKBP-type  
immunophilin is FKBP-12.

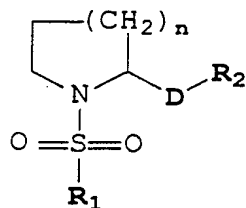
25 5. The method of claim 1, wherein the vision  
disorder is selected from the group consisting of: visual  
impairments; orbital disorders; disorders of the lacrimal

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appartus; disorders of the eyelids; disorders of the  
conjunctiva; disorders of the cornea; cataract; disorders  
of the uveal tract; disorders of the retina; disorders of  
the optic nerve or visual pathways; free radical induced  
5 eye disorders and diseases; immunologically-mediated eye  
disorders and disorders; eye injuries; and syptoms and  
complications of eye disease, eye disorder, or eye  
injury.

10 6. The method of claim 1, which is for improving  
naturally-occurring vision in an animal, in the absence  
of any opthalmologic disorder, disease, or injury.

15 7. The method of claim 1, wherein the N-linked  
sulfonamide of an N-heterocyclic carboxylic acid or  
isostere thereof is a compound having the formula (I):



I

where

20 n is 1-3;

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$R_1$  is selected from the group consisting of hydrogen,  $C_1-C_9$  straight or branched chain alkyl,  $C_2-C_9$  straight or branched chain alkenyl, aryl, heteroaryl, carbocycle, or heterocycle;

5  $D$  is a bond, or a  $C_1-C_{10}$  straight or branched chain alkyl,  $C_2-C_{10}$  alkenyl or  $C_2-C_{10}$  alkynyl;

$R_2$  is a carboxylic acid or a carboxylic acid isostere; wherein said alkyl, alkenyl, alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or carboxylic acid isostere is optionally substituted with one or more substituents selected from  $R^3$ , where

$R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1-C_6$  straight or branched chain alkyl,  $C_2-C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1-C_9$  straight or branched chain alkyl or alkenyl;

20 or a pharmaceutically acceptable salt, ester or solvate thereof.

8. The method of claim 7, wherein  $R_2$  is a carbocycle or heterocycle containing any combination of  $CH_2$ , O, S, or N in any chemically stable oxidation state, where any of the atoms of said ring structure are optionally

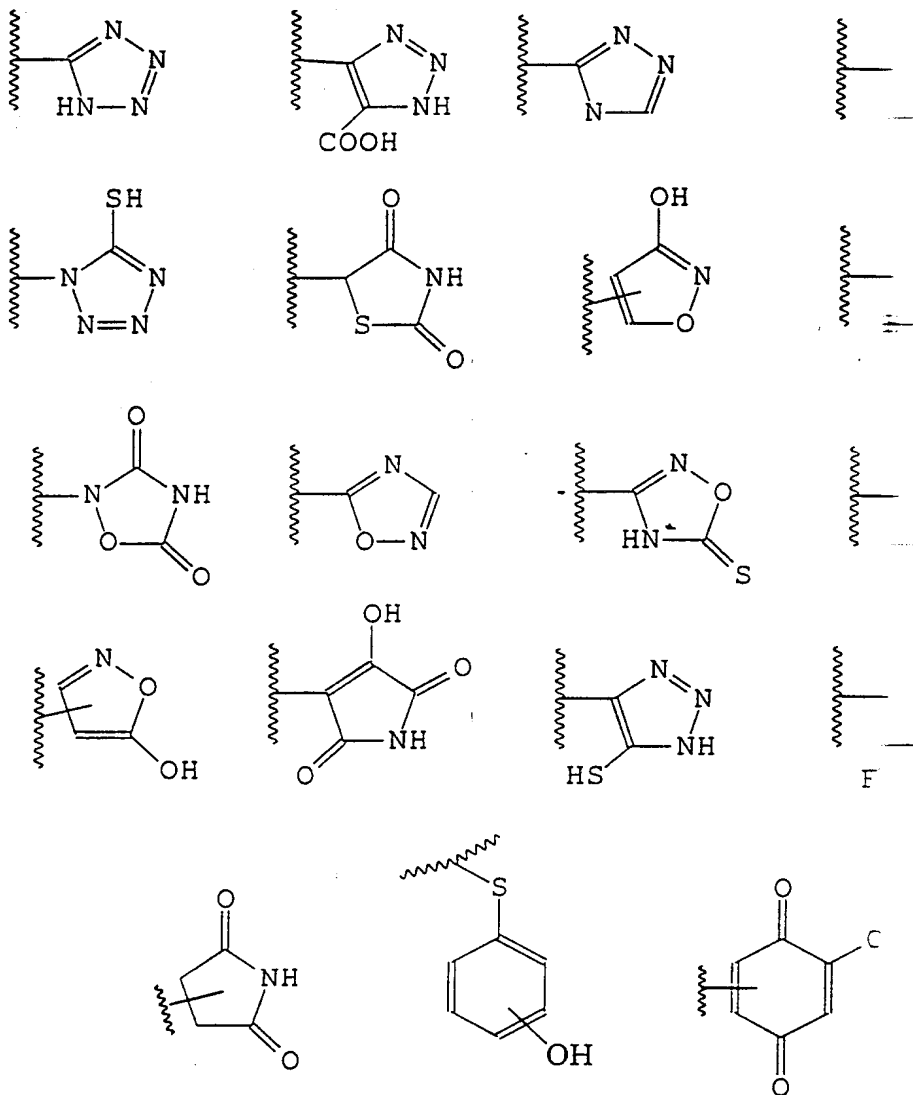
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substituted in one or more positions with  $R^3$ , wherein  
 $R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl,  
alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy,  
cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl,  
5 thioalkyl, alkylthio, sulfonyl,  $C_1-C_6$  straight or branched  
chain alkyl,  $C_2-C_6$  straight or branched chain alkenyl or  
alkynyl, aryl, heteroaryl, carbocycle, heterocycle, and  
 $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1-C_6$  straight or branched  
chain alkyl or alkenyl.

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9. The method of claim 7, wherein  $R_2$  is selected  
from the group below:

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where the atoms of said ring structure  $R_2$  may be optionally substituted at one or more positions with  $R^3$ , wherein

$R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1$ - $C_6$  straight or branched chain alkyl,  $C_2$ - $C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, and  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1$ - $C_6$  straight or branched chain alkyl or alkenyl.

10. The method of claim 7, wherein  $R_2$  is selected from the group consisting of  $-COOH$ ,  $-SO_3H$ ,  $-SO_2HNR^3$ ,  $-PO_2(R^3)_2$ ,  $-CN$ ,  $-PO_3(R^3)_2$ ,  $-OR^3$ ,  $-SR^3$ ,  $-NHCOR^3$ ,  $-N(R^3)_2$ ,  $-CON(R^3)_2$ ,  $-CONH(O)R^3$ ,  $-CONHNHSO_2R^3$ ,  $-COHNSO_2R^3$ , and  $-CONR^3CN$ .

11. The method of claim 7, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof is selected from the group consisting of:

(2S)-1-(phenylmethyl)sulfonyl-2-hydroxymethyl pyrrolidine;

(2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinetetrazole; and compounds 1-97 disclosed herein.

12. A pharmaceutical composition for treating a vision disorder, improving vision, treating memory impairment or enhancing memory performance in an animal, comprising:

- 5 a) an effective amount for treating a vision disorder, improving vision, treating memory impairment or enhancing memory performance in an animal of a N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof; and
- 10 b) a pharmaceutically acceptable carrier.

13. The pharmaceutical composition of claim 12, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof is immunosuppressive

15 or non-immunosuppressive.

14. The pharmaceutical composition of claim 12, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof has an affinity for

20 an FKBP-type immunophilin.

15. The pharmaceutical composition of claim 14, wherein the FKBP-type immunophilin is FKBP-12.

25 16. The pharmaceutical composition of claim 12, wherein the vision disorder is selected from the group

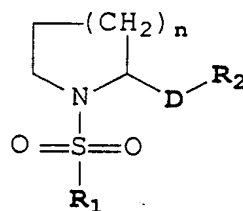


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consisting of: visual impairments; orbital disorders;  
disorders of the lacrimal apparatus; disorders of the  
eyelids; disorders of the conjunctiva; disorders of the  
cornea; cataract; disorders of the uveal tract; disorders  
of the retina; disorders of the optic nerve or visual  
pathways; free radical induced eye disorders and  
diseases; immunologically-mediated eye disorders and  
disorders; eye injuries; and symptoms and complications of  
eye disease, eye disorder, or eye injury.

17. The pharmaceutical composition of claim 12,  
which is for improving naturally-occurring vision in an  
animal, in the absence of any ophthalmologic disorder,  
disease, or injury.

18. The pharmaceutical composition of claim 12,  
wherein the N-linked sulfonamide of an N-heterocyclic  
carboxylic acid or isostere thereof comprises a compound  
of formula (I):



I

where

n is 1-3;

R<sub>1</sub> is selected from the group consisting of hydrogen, C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>9</sub> straight or branched chain alkenyl, aryl, heteroaryl, carbocycle, or heterocycle;

D is a bond, or a C<sub>1</sub>-C<sub>10</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>10</sub> alkenyl or C<sub>2</sub>-C<sub>10</sub> alkynyl;

R<sub>2</sub> is a carboxylic acid or a carboxylic acid isostere;

wherein said alkyl, alkenyl, alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or carboxylic acid isostere is optionally substituted with one or more substituents selected from R<sup>3</sup>, where

R<sup>3</sup> is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl, C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>6</sub> straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or CO<sub>2</sub>R<sup>4</sup> where R<sup>4</sup> is hydrogen or C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl or alkenyl;

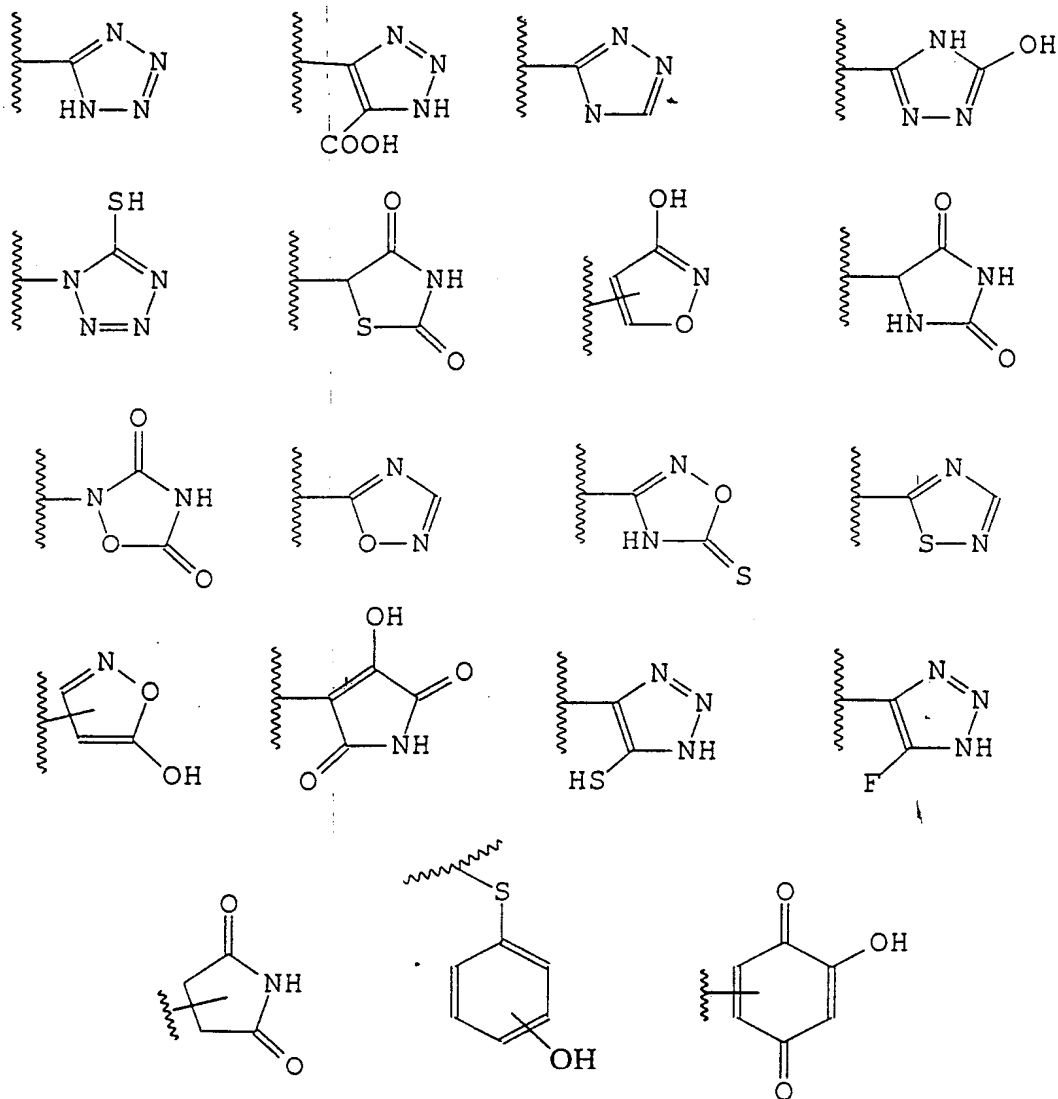
or a pharmaceutically acceptable salt, ester or solvate thereof.

19. The pharmaceutical composition of claim 18, wherein R<sub>2</sub> is a carbocycle or heterocycle containing any

combination of CH<sub>2</sub>, O, S, or N in any chemically stable oxidation state, wherein any of the atoms of said ring structure are optionally substituted in one or more positions with R<sup>3</sup>.

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20. The pharmaceutical composition of claim 18,  
wherein R<sub>2</sub> is selected from the following group:



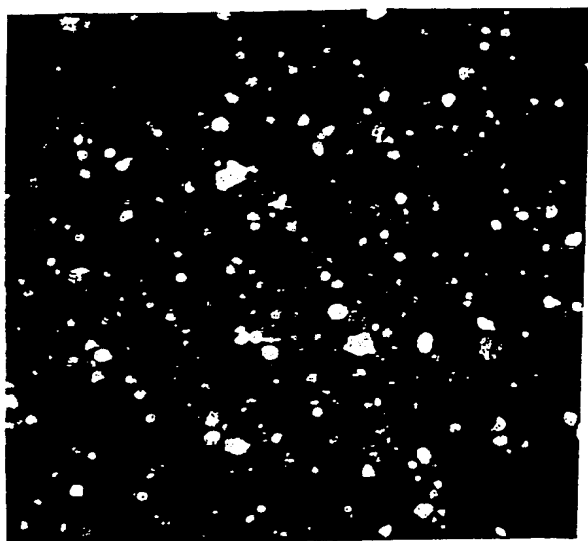
where the atoms of said ring structure may be optionally substituted at one or more positions with  $R^3$ .

21. The pharmaceutical composition of claim 18,  
5 wherein  $R_2$  is selected from the group consisting of:  
-COOH; -SO<sub>3</sub>H; -SO<sub>2</sub>HNR<sup>3</sup>; -PO<sub>2</sub>(R<sup>3</sup>)<sub>2</sub>; -CN; -PO<sub>3</sub>(R<sup>3</sup>)<sub>2</sub>; -OR<sup>3</sup>; -  
SR<sup>3</sup>; -NHCOR<sup>3</sup>; -N(R<sup>3</sup>)<sub>2</sub>; -CON(R<sup>3</sup>)<sub>2</sub>; -CONH(O)R<sup>3</sup>; -CONHNHSO<sub>2</sub>R<sup>3</sup>;  
-COHNSO<sub>2</sub>R<sup>3</sup>; and -CONR<sup>3</sup>CN.

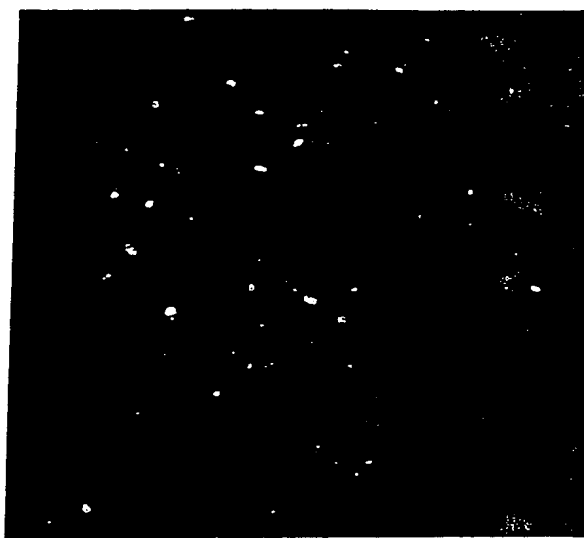
10 22. The pharmaceutical composition of claim 18,  
wherein the N-linked sulfonamide of an N-heterocyclic  
carboxylic acid or isostere thereof is selected from the  
group consisting of:  
(2S)-1-(phenylmethyl)sulfonyl-2-hydroxymethyl  
15 pyrrolidine;  
(2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinetetrazole; and  
compounds 1-97 disclosed herein.

Figure 1

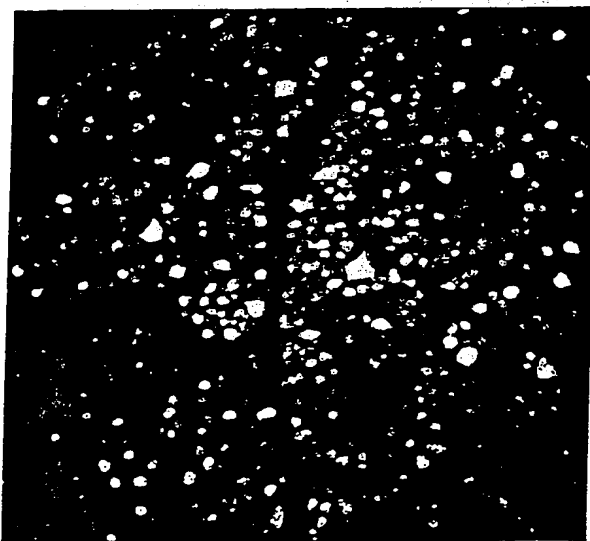
GPI 1046 protects ganglion cells against degeneration due to 1 hour of retinal ischemia  
Fluorogold labelled retinal ganglion cells in wholemount, 28 days after ischemic episode



A. Labelled retinal ganglion cells in the  
Normal central retina

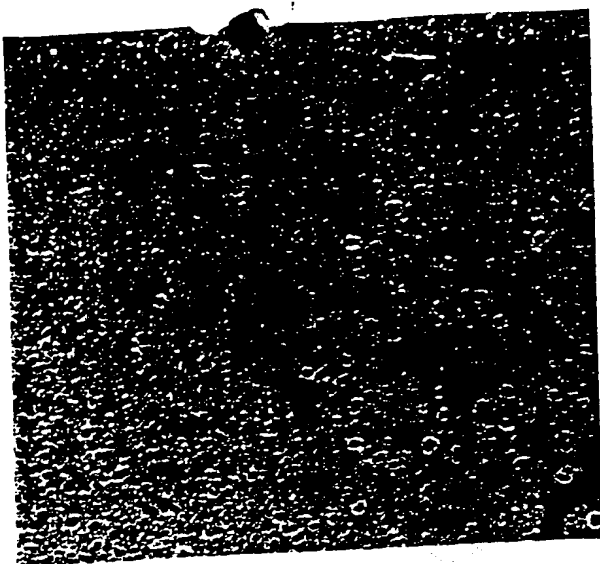


B. 1 hour of retinal ischemia produces  
extensive loss of ganglion cells

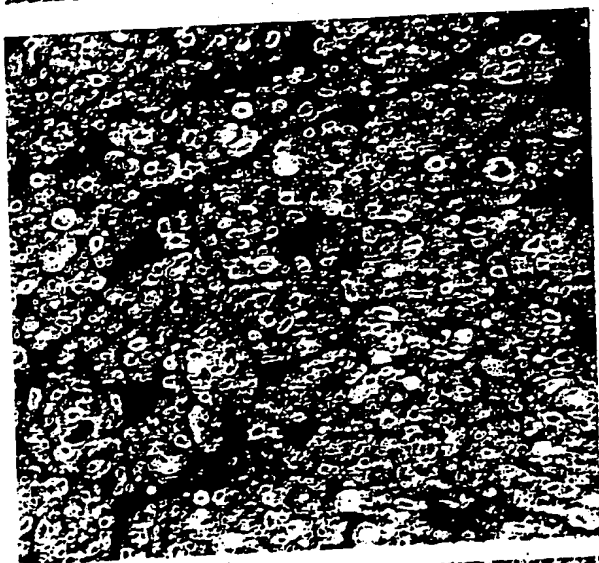


B. Administration of GPI 1046 1 hour before retinal ischemia  
and for 4 days subsequently produces significant protection of vulnerable retinal ganglion cells

GPI 1046 Protects retinal ganglion cell axons and prevents myelin degeneration  
in the optic nerve induced by 1 hour of complete retinal ischemia,  
toluidine blue stained optic nerve cross sections, 630X



C. GPI 1046 treated optic nerve 28 days  
after 1 hour complete retinal ischemia



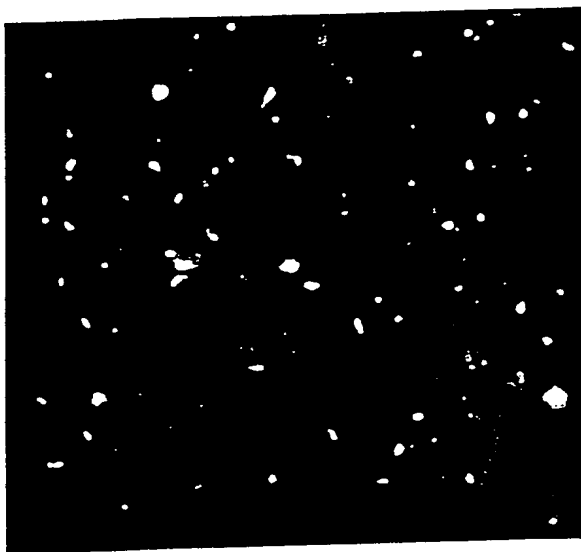
B. Vehicle treated optic nerve 28 days  
after 1 hour complete retinal ischemia



A. Normal optic nerve

Figure 3

**GPI 1046 administration for 28 days  
provides only moderate protection of  
axotomized retinal ganglion cells**



Florogold labelled RGCs 90 days following transection.  
Treatment with vehicle alone for 1<sup>st</sup> 28 days

Florogold labelled RGCs 90 days following transection.  
Treatment with GPI 1046 for 1<sup>st</sup> 28 days  
Treatment with vehicle alone for 1<sup>st</sup> 28 days

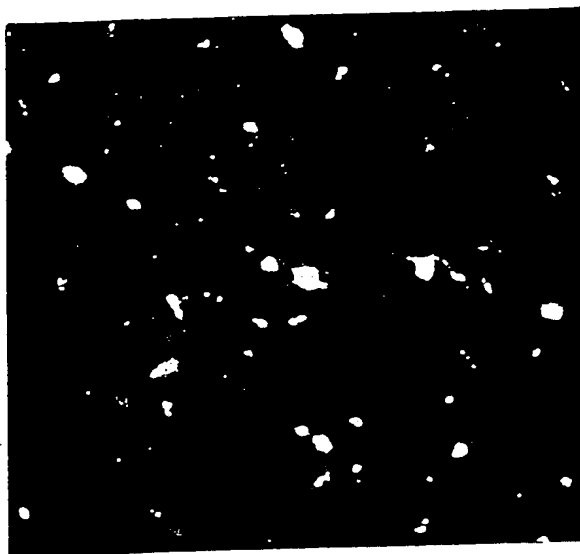
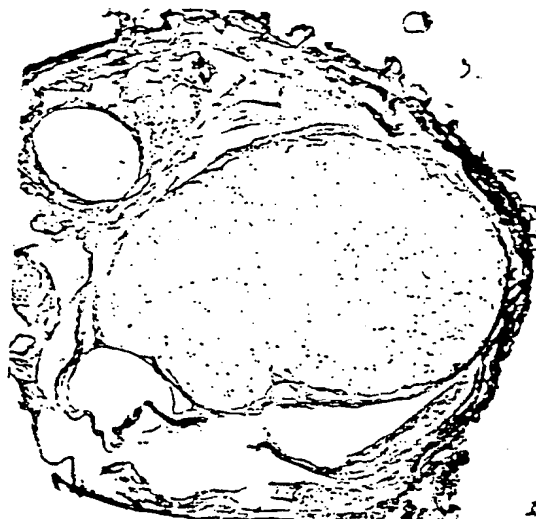


Figure 4

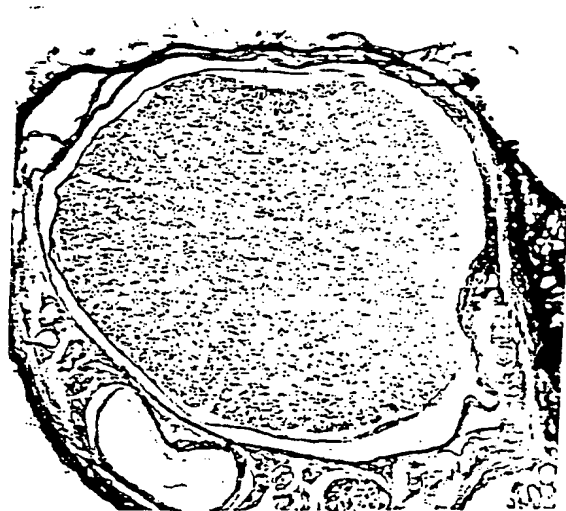
GPI 1046 prevents axonal degeneration in the proximal stump of the optic nerve  
RT97 neurofilament immunohistochemistry,  
optic nerve cross sections, 90 days after complete transection



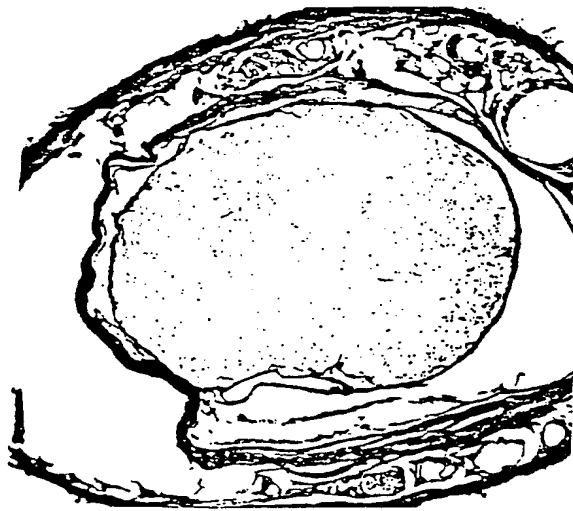
A. Sham



B. Optic nerve transection (ONT) 90 days survival



C. optic nerve 90 days after transection,  
GPI 1046 treatment days 1-28



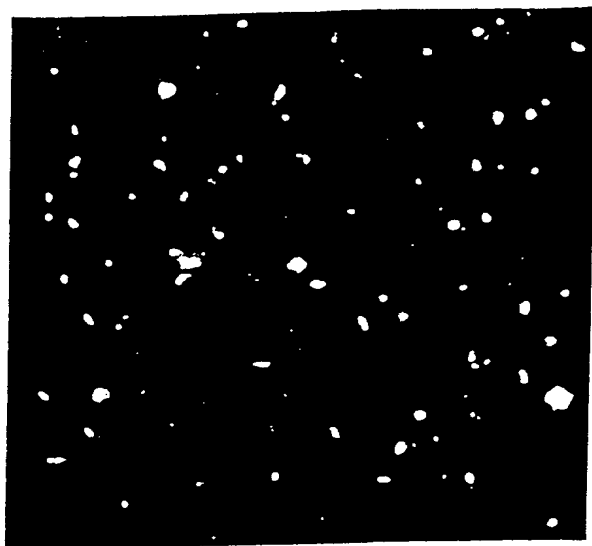
D. optic nerve 90 days after transection,  
GPI 1046 treatment days 1-14



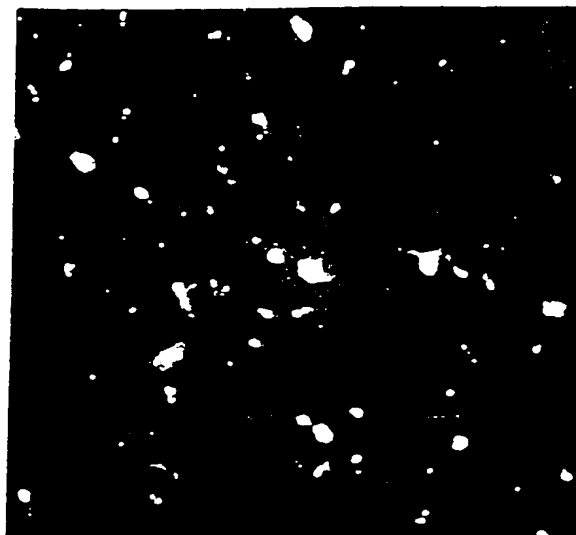
Figure 5

**GPI 1046 administration for 28 days provides only moderate protection  
of axotomized retinal ganglion cells**

Fluorogold labelled retinal ganglion cells 90 days following transection



vehicle administered for 1<sup>st</sup> 28 days



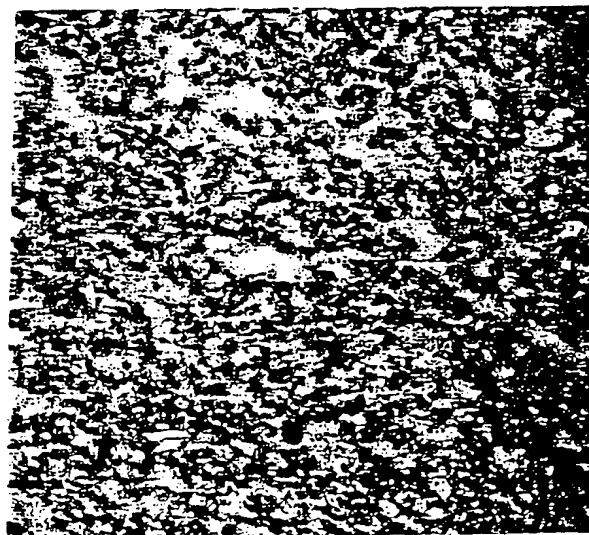
GPI 1046 administered for 1<sup>st</sup> 28 days

**GPI 1046 administration for 28 days preserves optic nerve axons  
of surviving retinal ganglion cells**

RT 97 neurofilament immunohistochemistry 90 days after transection



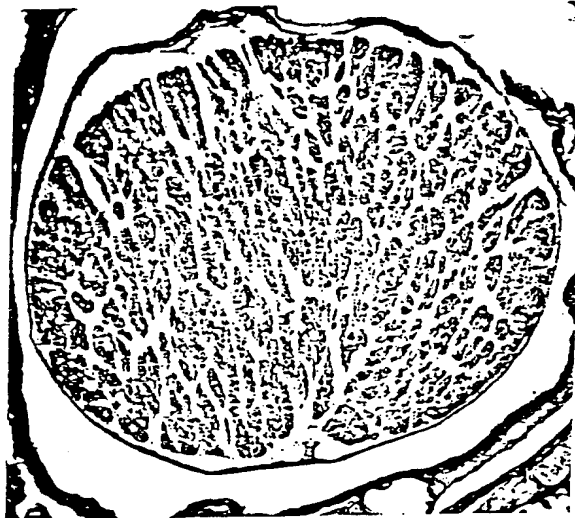
vehicle administered for 1<sup>st</sup> 28 days



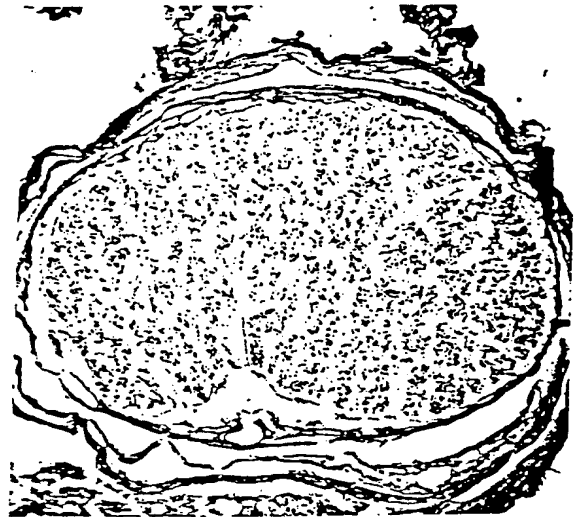
GPI 1046 administered for 1<sup>st</sup> 28 days

Figure 6

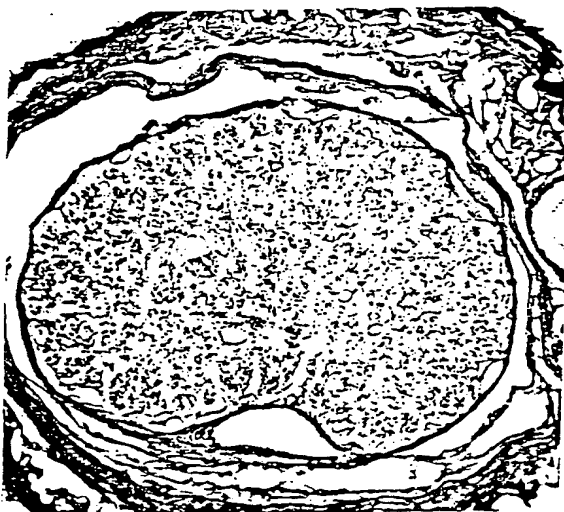
Preservation of myelin in the proximal stump of the optic nerve 90 days after transection  
14 vs 28 days treatment with GPI 1046 10mg/kg s.c.



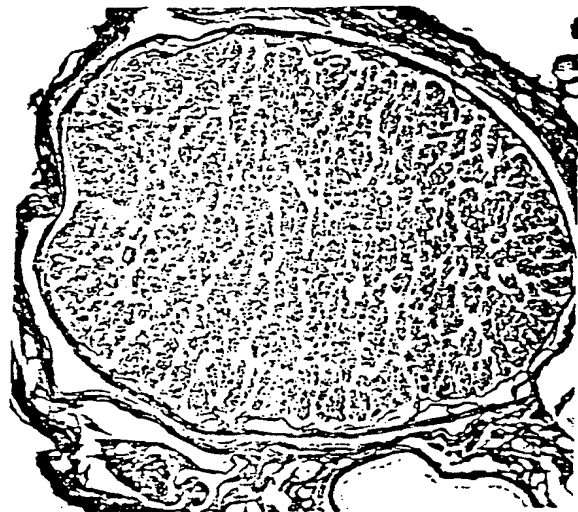
Normal( sham) Optic nerve



90 days after optic nerve transection. vehicle treated



90 days after optic nerve transection. 14 days GPI 1046



90 days after optic nerve transection. 28 days GPI 1046

myelin basic protein immunohistochemistry (SMI-94), 20X

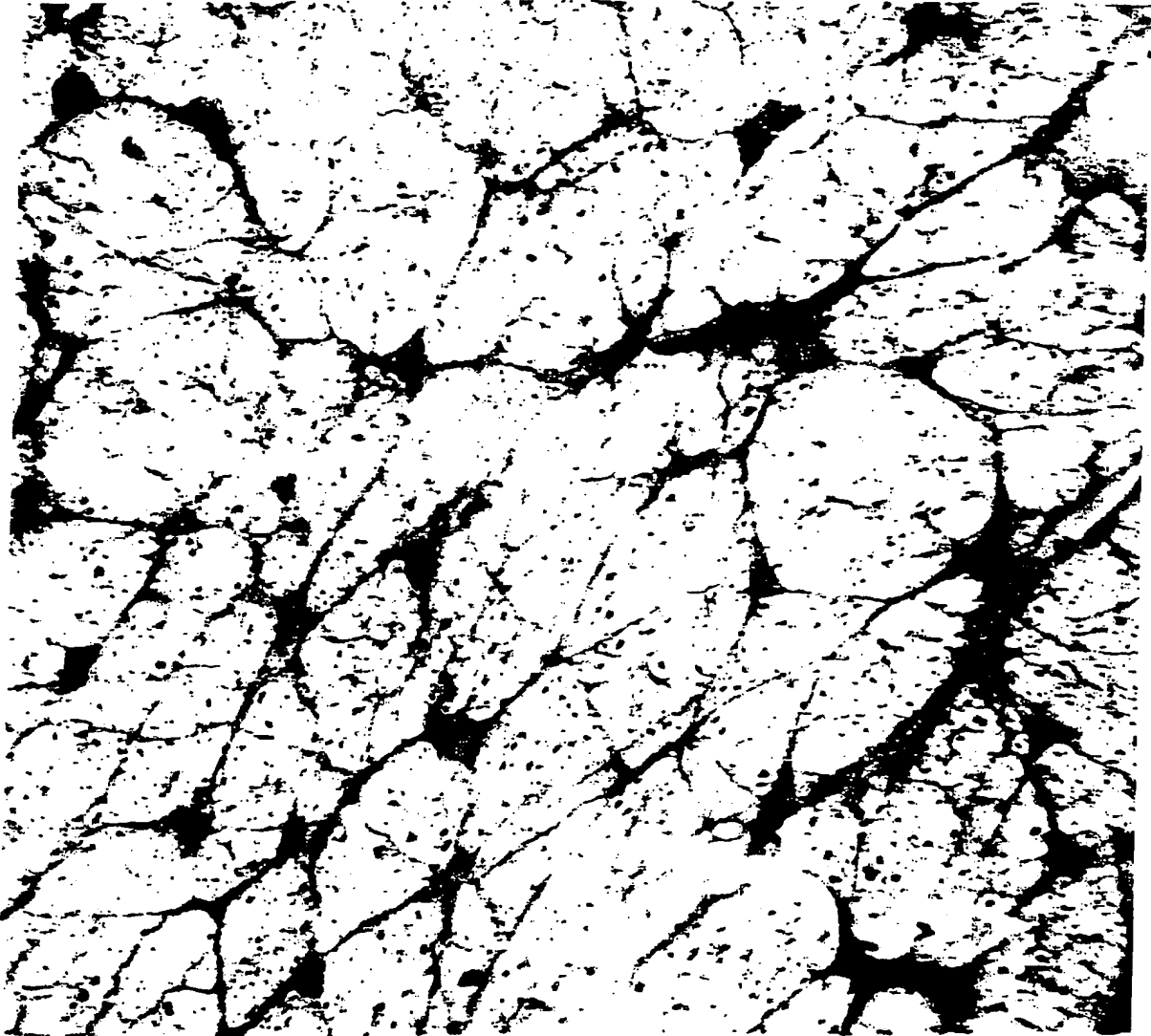


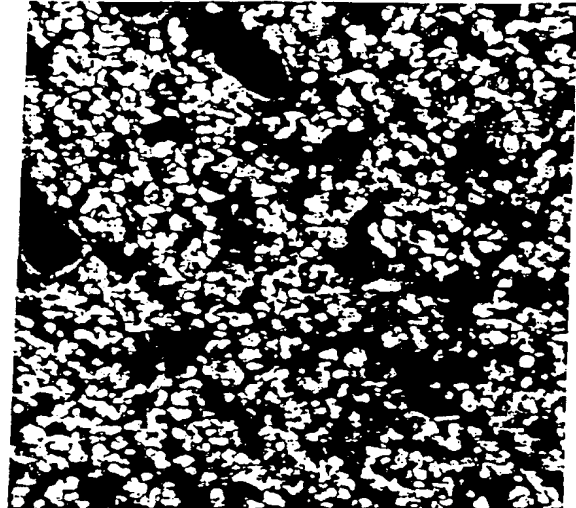
Figure 7  
FKBP-12 immunohistochemistry labels oligodendroglia and axons in the normal optic nerve

Figure 8

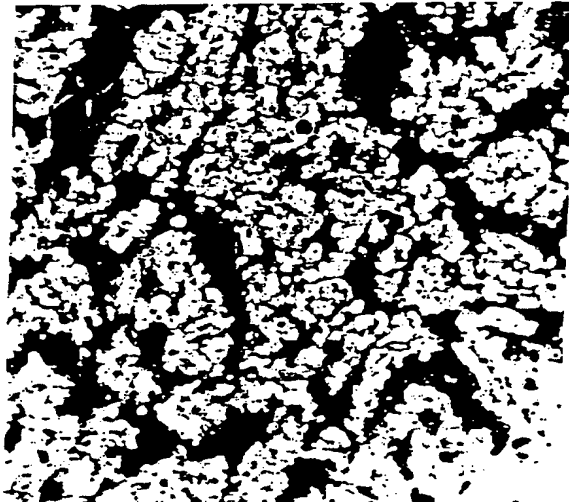
GPI 1046 treatment prevents myelin degeneration  
in the distal stump of the optic nerve  
Myelin basic protein immunohistochemistry 90 days after transection



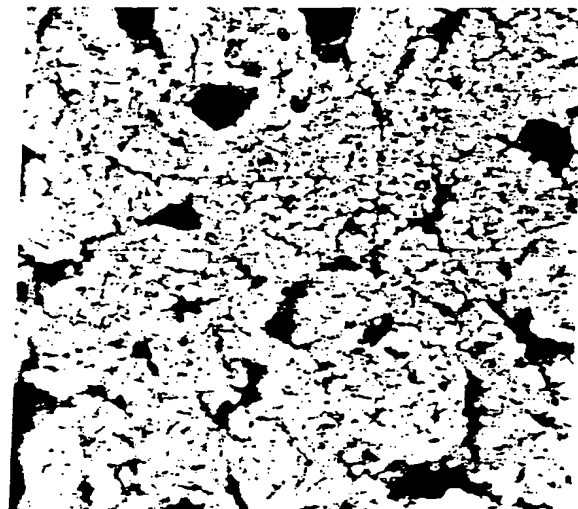
A. Normal optic nerve



B. Distal optic nerve stump  
90 days after complete transection



C. Distal optic nerve stump  
90 days after complete transection  
GPI 1046 administered 1-14 days  
after transection



D. Distal optic nerve stump  
90 days after complete transection  
GPI 1046 administered 1-28 days  
after transection

Figure 9

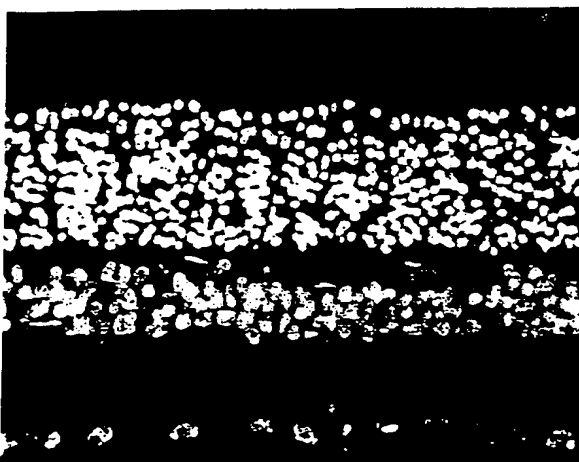
**GPI 1046 decreases neovascularization and prevents neuronal loss in the inner retina in the Streptozotocin model of diabetic retinopathy**

**A. Normal  
retina  
Cross section  
Cresyl violet**

Outer Nuclear  
layer (ONL)

Inner Nuclear  
layer (INL)

Ganglion cell  
layer (GCL)

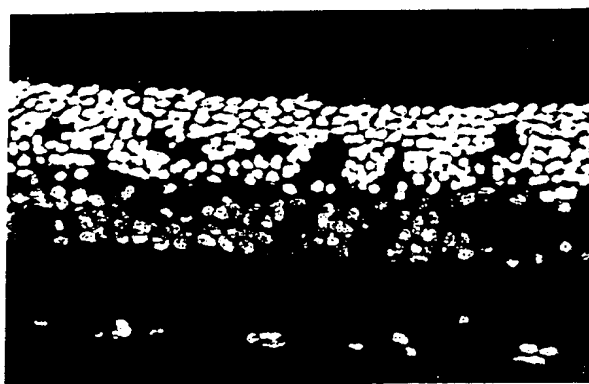


**B. retina from  
Streptozotocin  
/vehicle case**

ONL

INL

GCL

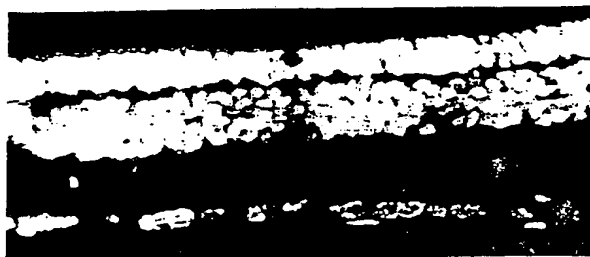


**C. Retina from  
Streptozotocin  
/GPI 1046 case**

ONL

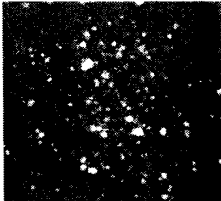
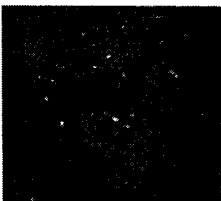
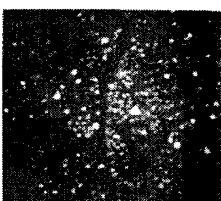
INL

GCL





## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|   |           |   |
|---|-----------|---|
| <b>(51) International Patent Classification <sup>7</sup> :</b><br><b>A61K 31/40, 31/425, 31/445, 31/44, A61P 27/02, 25/27</b>   | <b>A3</b> | <b>(11) International Publication Number:</b> <b>WO 00/09103</b><br><b>(43) International Publication Date:</b> 24 February 2000 (24.02.00)   |
| <b>(21) International Application Number:</b> PCT/US99/18231<br><b>(22) International Filing Date:</b> 12 August 1999 (12.08.99)<br><b>(30) Priority Data:</b><br>09/134,471 14 August 1998 (14.08.98) US<br><b>(71) Applicant:</b> GUILFORD PHARMACEUTICALS INC.<br>[US/US]; 6611 Tributary Street, Baltimore, MD 21224 (US).<br><b>(72) Inventors:</b> ROSS, Douglas, T.; 316 South Main Street, North Wales, PA 19454 (US). SAUER, Hansjorg; 10617 Lorraine Avenue, Silver Spring, MD 20901 (US). HAMILTON, Gregory, S.; 6501 Frederick Road, Catonsville, MD 21228 (US). STEINER, Joseph, P.; 4150 Louisville Road, Finksburg, MD 21048 (US).<br><b>(74) Agent:</b> NATH, Gary, M.; Nath & Associates, 6th Floor, 1030 15th Street, N.W., Washington, DC 20005-1503 (US). |           | <b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).<br><br><b>Published</b><br><i>With international search report.</i><br><br><b>(88) Date of publication of the international search report:</b><br>16 November 2000 (16.11.00) |
| <b>(54) Title:</b> N-LINKED SULFONAMIDES OF N-HETEROCYCLIC CARBOXYLIC ACIDS OR ISOSTERES FOR VISION AND MEMORY DISORDERS<br><br><b>(57) Abstract</b><br><p>This invention relates to novel compositions and uses of an N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof for treating a vision disorder or improving vision or treating memory impairment or enhancing memory performance in an animal.</p> <div data-bbox="909 1165 1193 1858"><p>A</p><p>B</p><p>C</p></div>        |           |   |

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/18231

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61K31/40 A61K31/425 A61K31/445 A61K31/44 A61P27/02  
A61P25/27

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
|------------|---|-----------------------|
| X          | WO 98 29116 A (GUILFORD PHARM INC)<br>9 July 1998 (1998-07-09)<br>abstract<br>page 3, line 19 -page 27, line 5<br>page 42, line 24 -page 43, line 12<br>---<br>-/-- | 1-7,10,<br>12-18,21   |

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

4 April 2000

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 99/18231

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| X          | <p>DERUITER, JACK; BRUBAKER, ABRAM N.;<br/>GARNER, MARTHA A.; BARKSDALE, -JEFFREY M.;<br/>MAYFIELD, CHARLES A.: "In vitro aldose<br/>reductase inhibitory activity of<br/>substituted N-benzenesulfonylglycine<br/>derivatives"<br/>J. PHARM. SCI.,<br/>vol. 76, no. 2, - 1987 pages 149-152,<br/>XP000876666<br/>abstract; tables 1,2<br/>see compounds 8a-8d<br/>page 149, column 1, paragraph 1 -column 2,<br/>paragraph 1</p> <p style="text-align: center;">---</p> | 1-7,10,<br>12-18,21   |
| X          | <p>NICOLAIDES, E. D. ET AL: "Modified di-<br/>and tripeptides of the C-terminal portion<br/>of oxytocin and vasopressin as possible<br/>cognition activation agents"<br/>J. MED. CHEM. (1986), 29(6), 959-71,1986,<br/>XP000876698<br/>abstract; table 2</p> <p style="text-align: center;">---</p>  | 1                     |
| X          | <p>DE 44 25 950 A (BAYER AG)<br/>25 January 1996 (1996-01-25)<br/>abstract; claims 1-4; examples 1-24; table<br/>1</p> <p style="text-align: center;">---</p>  | 1-7,10,<br>12-18,21   |
| X          | <p>WO 96 40140 A (GUILFORD PHARM INC ;UNIV<br/>JOHNS HOPKINS MED (US))<br/>19 December 1996 (1996-12-19)<br/>page 17, line 33 -page 18, line 11<br/>page 57; example 55</p> <p style="text-align: center;">---</p>   | 1-22                  |
| P,X        | <p>EP 0 915 086 A (ONO PHARMACEUTICAL CO)<br/>12 May 1999 (1999-05-12)<br/>abstract<br/>page 85, line 22-41<br/>page 101, line 1-20<br/>&amp; WO 97 45402 A (ONO PHARM CO LTD)<br/>4 December 1997 (1997-12-04)<br/>the whole document</p> <p style="text-align: center;">---</p>  | 1-7,10,<br>12-18,21   |
| X          | <p>the whole document</p> <p style="text-align: center;">---</p> <p style="text-align: center;">-/--</p>   | 1-7,10,<br>12-18,21   |

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/18231

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
|------------|---|-----------------------|
| P,X        | WO 99 14998 A (AMGEN INC ;MAGAL ELLA (US))<br>1 April 1999 (1999-04-01)<br>page 233 -page 234; examples 25-29<br>page 230, line 5 -page 231, line 5<br>page 211, line 5 -page 220, line 8; table XLVIII<br>page 195, line 6 -page 196, line 21<br>page 178, line 1 -page 182, line 26<br>page 172, line 8 -page 176, line 2<br>page 107, line 8 -page 121, line 10<br>claims 27, 31-40, 49, 50, 54, 56, 58, 84-94, 106, 111, 113-115, 141-151, 163, 164, 168, 170<br>abstract | 12-22                 |
| E          | WO 99 62880 A (AMGEN INC ;GUILFORD PHARM INC (US)) 9 December 1999 (1999-12-09)<br>abstract; claims 1-13; table 1   | 12-22                 |
| P,X        | WO 99 32451 A (AMGEN INC ;HUMMEL CONRAD (US); KOCH KEVIN (US); TERMIN ANDREAS (US))<br>1 July 1999 (1999-07-01)<br>abstract<br>page 1, line 15-32<br>page 5, line 15 -page 42, line 10<br>page 136, line 7-19<br>page 131, line 40 -page 133, line 21   | 1-7,10,<br>12-18,21   |
| P,X        | WO 99 65451 A (SMITHKLINE BEECHAM CORP ;LEE DENNIS (US); LONG SCOTT A (US))<br>23 December 1999 (1999-12-23)<br>claims 1-13; table 1  | 12-22                 |
| P,X        | WO 99 10340 A (VERTEX PHARMA)<br>4 March 1999 (1999-03-04)<br>abstract<br>page 6, line 1 -page 10, line 13<br>page 19, line 14 -page 20, line 6; claims 2,14; example 1<br>table 2  | 12-21                 |
| X          | WO 98 16502 A (ALBRECHT HANS P ;WALKER NIGEL (DE); ALLEN HAMISH JOHN (US); HARTER) 23 April 1998 (1998-04-23)<br>abstract<br>page 18, line 19,20  | 12-21                 |
| X          | US 5 721 256 A (LI JIA-HE ET AL)<br>24 February 1998 (1998-02-24)<br>column 11, line 26-38<br>claims 5,17; examples 1-4; tables 1-3   | 1-22                  |
|            | ---   |                       |
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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 99/18231

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
|------------|---|-----------------------|
| E          | WO 99 62490 A (GUILFORD PHARM INC)<br>9 December 1999 (1999-12-09) -<br>page 14, line 1 -page 19, line 17; tables<br>1,2  | 12-22                 |
| P,X        | ---<br>WO 99 06390 A (LOMBARDO LOUIS JOHN ;SEMKO<br>CHRISTOPHER M (US); THORSETT EUGENE D ( )<br>11 February 1999 (1999-02-11)<br>examples 140-145, 147-152, 154-160, 162,<br>163, 165, 166-186, 192, 193, 195, 196<br>claims 1-34<br>examples 1-10,21-22 27, 30, 32, 33, 35,<br>39, 40-45, 56-58, 62, 63, 69, 72, 77, 80,<br>81, 83, 86, 87, 89, 93-101, 109, 111, 117,<br>132, 137<br>page 161, line 17 -page 162, line 5; table<br>2<br>page 14, line 20 -page 40, line 9; table<br>IA | 1-7,10,<br>12-18,21   |
| P,X        | ---<br>WO 99 06431 A (LOMBARDO LOUIS JOHN ;SEMKO<br>CHRISTOPHER M (US); THORSETT EUGENE D ( )<br>11 February 1999 (1999-02-11)<br>page 27, line 21 -page 36, line 31; table<br>1  | 1-7,10,<br>12-18,21   |
| P,X        | ---<br>WO 99 06432 A (LOMBARDO LOUIS JOHN ;SEMKO<br>CHRISTOPHER M (US); THORSETT EUGENE D ( )<br>11 February 1999 (1999-02-11)<br>page 15, line 9 -page 20, line 14; claims<br>1-16; examples 1-8,12-16; table I  | 1-7,10,<br>12-18,21   |
| P,X        | ---<br>WO 99 06434 A (LOMBARDO LOUIS JOHN ;SEMKO<br>CHRISTOPHER M (US); THORSETT EUGENE D ( )<br>11 February 1999 (1999-02-11)<br>page 13, line 18 -page 21, line 2; claims<br>1-26; examples 1-14,24; tables I,II  | 1-7,10,<br>12-18,21   |
| P,X        | ---<br>WO 99 06435 A (SEMKO CHRISTOPHER M<br>;THORSETT EUGENE D (US); AMERICAN HOME<br>PROD (U) 11 February 1999 (1999-02-11)<br>page 84, line 1-11; claims 1-18; examples<br>1,3-16; tables 1,2  | 1-7,10,<br>12-18,21   |
| P,X        | ---<br>WO 99 06436 A (LOMBARDO LOUIS JOHN ;SEMKO<br>CHRISTOPHER M (US); THORSETT EUGENE D ( )<br>11 February 1999 (1999-02-11)<br>page 10, line 26 -page 16, line 6; claims<br>1-14; table 1  | 1-7,10,<br>12-18,21   |
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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/18231

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| P,X        | WO 99 06437 A (SEMKO CHRISTOPHER M<br>;THORSETT EUGENE D (US); KREFF ANTHONY<br>(US); A) 11 February 1999 (1999-02-11)<br>examples 1-29, 31-229, 236-242<br>page 148, line 18 -page 149, line 2<br>page 5, line 1 -page 38, line 4; tables<br>IA,IB<br>--- | 1-7,10,<br>12-18,21   |
| X          | WO 97 21690 A (CEPHALON INC)<br>19 June 1997 (1997-06-19)<br>page 2, line 1-15; claims 1-43; examples<br>84-86,94-96,102,103,105,111,112<br>---  | 1-7,10,<br>12-18,21   |
| P,X        | WO 98 50348 A (AGOURON PHARMA ;BENDER<br>STEVEN L (US))<br>12 November 1998 (1998-11-12)<br>page 4, line 28 -page 5, line 8; claims<br>1-13,21; examples 5-7<br>---  | 1-7,10,<br>12-18,21   |
| X          | WO 98 08823 A (PROCTER & GAMBLE)<br>5 March 1998 (1998-03-05)<br>page 18, paragraphs 5,8; claims 1-10;<br>examples 1-65<br>abstract<br>-----   | 1-6,10,<br>12-18,21   |

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 99/18231

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:

Although claims 1-11 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

2. ☒ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

See FURTHER COMMUNICATION SHEET PCT/ISA/210

3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
- 1-4, 7-22 (partially), 5, 6

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

1. Claims: 1-4,7-22 (partially), 5,6

Pharmaceutical composition and use in therapy of a N-linked sulfonamide of N-heterocyclic carboxylic acid or isostere thereof for the treatment of vision disorders and to improve vision.

2. Claims: 1-4, 7-22 (partially)

Pharmaceutical composition and use in therapy of a N-linked sulfonamide of N-heterocyclic carboxylic acid or isostere thereof for treatment of memory impairment, and to enhance the memory performance in an animal.

## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 2.10

Continuation of Box 3.

Although claims 1-11 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

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Further defect(s) under Article 17(2)(a):

Continuation of Box 3.

Present claims 1-6,12-17 relate to an extremely large number of possible compounds/uses/compositions. Support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT is to be found, however, for only a very small proportion of the compounds/uses/compositions claimed. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible.

Present claims 2-4,13-15 relate to a compound/use defined (inter alia) by reference to the following parameter(s):

P1: immunosuppressive or non-immunosuppressive.

P2: affinity for an FKBP-type immunophilin

P3: affinity for FKBP-12 immunophilin

The use of these parameters in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameters the applicant has chosen to employ with what is set out in the prior art. The lack of clarity is such as to render a meaningful complete search impossible.

Consequently, the search has been restricted to compounds/compositions/uses of examples 1-5, C and D, the compounds specifically mentioned in the claims and the diseases specifically mentioned in the claims with due regard to the description.

According to Rule 6.2.a. PCT, claims shall not, except where absolutely necessary, rely on references to the description. Therefore, the part "and compounds 1-94 disclosed herein" in claims 11 and 22 has been disregarded.

The term "isostere" is used rather loosely in the present application: according to its usual meaning in the art, isosteres have the common meaning of having the same number of atoms, (peripheral) electrons, and charge. In the present context, the term "isostere" is to be construed in the larger sense of "bioisosteres".

The pharmaceutically skilled man knows that e.g. the carboxylic acid function and the tetrazolyl group are bioisosteric, and expects these bioisosteres to have a similar biological activity. However, this term does not allow the skilled man to list exhaustively all the possible bioisosteres of said groups of compounds. Therefore the scope of the claims for which protection is sought is not clearly delimited. Furthermore the use of the term isostere in the present context tends to

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 21a

define the compounds/uses for which protection is sought by a result to be achieved.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.



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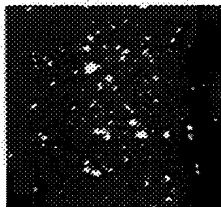
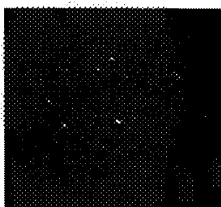
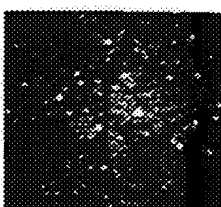
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| <b>(54) Title:</b> N-LINKED SULFONAMIDES OF N-HETEROCYCLIC CARBOXYLIC ACIDS OR ISOSTERES FOR VISION AND MEMORY DISORDERS<br><br><b>(57) Abstract</b><br><p>This invention relates to novel compositions and uses of an N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof for treating a vision disorder or improving vision or treating memory impairment or enhancing memory performance in an animal.</p> <div data-bbox="922 1171 1198 1852"><p>A </p><p>B </p><p>C </p></div>    |           |  |

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N-LINKED SULFONAMIDES OF N-HETEROCYCLIC  
CARBOXYLIC ACIDS OR ISOSTERES  
FOR VISION AND MEMORY DISORDERS

5

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to pharmaceutical compositions and methods for treating vision loss, preventing vision  
10 degeneration, and promoting vision regeneration ("neopsis") using low molecular weight, small molecule derivatives.

2. Description of Related Art

The visual system is composed of the eyes, ocular adnexa  
15 and the visual pathways. Dysfunction of the visual system may lead to permanent or temporary visual impairment, i.e. a deviation from normal in one or more functions of the eye. Visual impairment manifests itself in various ways and includes a broad range of visual dysfunctions and  
20 disturbances. Without limitation, these dysfunctions and disturbances include partial or total loss of vision, the need for correction of visual acuity for objects near and far, loss of visual field, impaired ocular motility without diplopia (double vision), impaired or skewed color  
25 perception, limited adaptation to light and dark, diminished accommodation, metamorphopsic distortion, impaired binocular vision, paresis of accommodation, iridoplegia, entropion, ectropion, epiphora, lagophthalmos, and scarring. See *Physicians' Desk Reference (PDR) for Ophthalmology*, 16th  
30 Edition, 6:47 (1988). The visual system may be adversely affected by various ophthalmologic disorders, diseases, injuries, and complications, including, without limitation, genetic disorders; [non-genetic disorders;] disorders associated with aging or degenerative diseases; disorders

correlating to physical injury to the eye, head, or other parts of the body resulting from external forces; disorders resulting from environmental factors; disorders resulting from a broad range of diseases; and combinations of any of the above.

The visual system is a complex system composed of numerous components. Visual impairment can involve the entire visual system, any one component, or any combination of components, depending upon the precise nature of the circumstances. The eye is composed of a lens, which is suspended in the zonules of Zinn and is focused by the ciliary body. The ciliary body also secretes aqueous humor, which fills the posterior chamber, passes through the pupil into the anterior chamber, then drains primarily via the canal of Schlemm. The iris regulates the quantity of light entering the eye by adjusting the size of its central opening, the pupil. A visual image is focused onto the retina, the fovea centralis being the retinal area of sharpest visual acuity. The conjunctiva is the mucus membrane which lines the eyelids and the eyeball, and ends abruptly at the limbus conjunctivae, the edge of the conjunctiva overlapping the cornea. The cornea is the clear, transparent anterior portion of the fibrous coat of the eye; it is important in light refraction and is covered with an epithelium that differs in many respects from the conjunctival epithelium.

The retina is the innermost, light sensitive portion of the eye, containing two types of photoreceptors, cones, which are responsible for color vision in brighter light, and rods, which are essential for vision in dim light but do not perceive colors. After light passes through the cornea, lens system, and the vitreous humor, it enters the retina from the inside; that is, it passes through the ganglion cells and nerve fibers, the inner and outer plexiform layers, the inner and outer nuclear layers, and the internal and external

limiting membranes before it finally reaches the layer of photoreceptors located near the outside of the retina, just inside the outermost pigment epithelium layer. The cells of the pigment epithelium layer act as an anatomical barrier to liquids and substances located outside of the eye, forming the "blood-retina" barrier, and provide nourishment, oxygen, a source of functionally useful substances like vitamin A, and phagocytosis of decomposition products to photoreceptor cells. There is no anatomical connection between the pigment epithelium and the photoreceptor layer, permitting separation of the layers in some pathological situations.

When rods or cones are excited by light, signals are transmitted through successive neurons in the retina itself, into the optic nerve fibers, and ultimately to the cerebral cortex. Both rods and cones contain molecules that decompose on exposure to light and, in the process, excite the nerve fibers leading from the eye. The molecule in rods is rhodopsin. The three light-sensitive molecules in cones, collectively called iodopsin, have compositions only slightly different from that of rhodopsin and are maximally excited by red, blue, or green light, respectively.

Neither rods nor cones generate action potentials. Rather, the light-induced membrane hyperpolarization generated in the outer, photosensitive segment of a rod or cone cell is transmitted from the outer segment through the inner segment to the synaptic body by direct conduction of the electrical voltage itself, a process called electrotonic conduction. At the synaptic body, the membrane potential controls the release of an unknown transmitter molecule. In low light, rod and cone cell membranes are depolarized and the rate of transmitter release is greatest. Light-induced hyperpolarization causes a marked decrease in the release of transmitter molecules.

The transmitters released by rod and cone cells induce signals in the bipolar neurons and horizontal cells. The



signals in both these cells are also transmitted by electrotonic conduction and not by action potential.

The rod bipolar neurons connect with as many as 50 rod cells, while the dwarf and diffuse bipolar cells connect with one or several cone cells. A depolarizing bipolar cell is stimulated when its connecting rods or cones are exposed to light. The release of transmitter molecules inhibits the depolarizing bipolar cell. Therefore, in the dark, when the rods and cones are secreting large quantities of transmitter molecules, the depolarizing bipolar cells are inhibited. In the light, the decrease in release of transmitter molecules from the rods and cones reduces the inhibition of the bipolar cell, allowing it to become excited. In this manner, both positive and negative signals can be transmitted through different bipolar cells from the rods and cones to the amacrine and ganglion cells.

As their name suggests, horizontal cells project horizontally in the retina, where they may synapse with rods, cones, other horizontal cells, or a combination of cells types. The function of horizontal cells is unclear, although some mechanism in the convergence of photoreceptor signaling has been postulated.

All types of bipolar cells connect with ganglion cells, which are of two primary types. A-type ganglion cells predominately connect with rod bipolar cells, while B-type ganglion cells predominately connect with dwarf and diffuse bipolar cells. It appears that A-type ganglion cells are sensitive to contrast, light intensity, and perception of movement, while B-type ganglion cells appear more concerned with color vision and visual acuity.

Like horizontal cells, the Amacrine cells horizontally synapse with several to many other cells, in this case bipolar cells, ganglion cells, and other Amacrine cells. The function of Amacrine cells is also unclear.

The axons of ganglion cells carry signals into the nerve

fiber layer of the eye, where the axons converge into fibers which further converge at the optic disc, where they exit the eye as the optic nerve. The ganglion cells transmit their signals through the optic nerve fibers to the brain in the form of action potentials. These cells, even when unstimulated, transmit continuous nerve impulses at an average, baseline rate of about 5 per second. The visual signal is superimposed onto this baseline level of ganglion cell stimulation. It can be either an excitatory signal, with the number of impulses increasing above the baseline rate, or an inhibitory signal, with the number of nerve impulses decreasing below the baseline rate.

As part of the central nervous system, the eye is in some ways an extension of the brain; as such, it has a limited capacity for regeneration. This limited regeneration capacity further complicates the challenging task of improving vision, resolving dysfunction of the visual system, and/or treating or preventing ophthalmologic disorders. Many disorders of the eye, such as retinal photic injury, retinal ischemia-induced eye injury, age-related macular degeneration, free radical-induced eye diseases, as well as numerous other disorders, are considered to be entirely untreatable. Other ophthalmologic disorders, e.g., disorders causing permanent visual impairment, are corrected only by the use of ophthalmic devices and/or surgery, with varying degrees of success.

The immunosuppressant drugs FK506, rapamycin, and cyclosporin are well known as potent T-cell specific immunosuppressants, and are effective against autoimmunity, transplant or graft rejection, inflammation, allergic responses, other autoimmune or immune-mediated diseases, and infectious diseases. It has been disclosed that application of Cyclosporin, FK-506, Rapamycin, Buspirone, Spiperone, and/or their derivatives are effective in treating some ophthalmologic disorders of these types. Several

ophthalmologic disorders or vision problems are known to be associated with autoimmune and immunologically-mediated activities; hence, immunomodulatory compounds are expected to demonstrate efficacy for treating those types of ophthalmologic disorders or vision problems.

The effects of FK506, Rapamycin, and related agents in the treatment of ophthalmologic diseases are disclosed in several U.S. patents (Goulet et al., U.S. Patent No. 5,532,248; Mochizuki et al., U.S. Patent No. 5,514,686; Luly et al., U.S. Patent No. 5,457,111; Russo et al., U.S. Patent No. 5,441,937; Kulkarni, U.S. Patent No. 5,387,589; Asakura et al., U.S. Patent No. 5,368,865; Goulet et al., U.S. Patent No. 5,258,389; Armistead et al., U.S. Patent No. 5,192,773; Goulet et al., U.S. Patent No. 5,189,042; and Fehr, U.S. Patent No. 5,011,844). These patents claim FK506 or Rapamycin related compounds and disclose the known use of FK506 or Rapamycin related compounds in the treatment of ophthalmologic disorders in association with the known immunosuppressive effects of FK506 and Rapamycin. The compounds disclosed in these patents are relatively large. Further, the cited patents relate to immunomodulatory compounds limited to treating autoimmunity or related diseases, or immunologically-mediated diseases, for which the efficacy of FK506 and Rapamycin is well known.

Other U.S. patents disclose the use of cyclosporin, Spiperone, Buspirone, their derivatives, and other immunosuppressive compounds for use in the treatment of ophthalmologic diseases (Sharpe et al., U.S. Patent No. 5,703,088; Sharpe et al., U.S. Patent No. 5,693,645; Sullivan, U.S. Patent No. 5,688,765; Sullivan, U.S. Patent No. 5,620,921; Sharpe et al., U.S. Patent No. 5,574,041; Eberle, U.S. Patent No. 5,284,826; Sharpe et al., U.S. Patent No. 5,244,902; Chiou et al., U.S. Patent Nos. 5,198,454 and 5,194,434; and Kaswan, U.S. Patent No. 4,839,342). These patents also relate to compounds useful for treating

autoimmune diseases and cite the known use of cyclosporin, Spiperone, Buspirone, their derivatives, and other immunosuppressive compounds in treating ocular inflammation and other immunologically-mediated ophthalmologic diseases.

5       The immunosuppressive compounds disclosed in the prior art suppress the immune system, by definition, and also exhibit other toxic side effects. Accordingly, there is a need for non-immunosuppressant, small molecule compounds, and compositions and methods for use of such compounds, that are  
10       useful in improving vision; preventing, treating, and/or repairing visual impairment or dysfunction of the visual system; and preventing, treating, and/or resolving ophthalmologic disorders.

          There are also a number of patents on non-  
15       immunosuppressive compounds disclosing methods of use for permitting or promoting wound healing (whether from injury or surgery); controlling intraocular pressure (often resulting from glaucoma); controlling neurodegenerative eye disorders, including damage or injury to retinal neurons, damage or  
20       injury to retinal ganglion cells, and macular degeneration; stimulating neurite outgrowth; preventing or reducing oxidative damage caused by free radicals; and treating impaired oxygen and nutrient supply, as well as impaired waste product removal, resulting from low blood flow. These  
25       non-immunosuppressive substances fall into one of two general categories: naturally occurring molecules, such as proteins, glycoproteins, peptides, hormones, and growth factors; and synthetic molecules.

          Within the group of naturally occurring non-  
30       immunosuppressive molecules, several hormones, growth factors, and signaling molecules have been patented for use as supplements to naturally occurring quantities of such molecules, as well as for targeting of specific cells where the particular molecule does not naturally occur in a mature  
35       individual. These patents generally claim methods of use for

reducing or preventing the symptoms of ocular disease, or arresting or reversing vision loss.

Specifically, Louis et al., U.S. Patent Nos. 5,736,516 and 5,641,749, disclose the use of a glial cell line derived  
5 neurotrophic factor (GDNF) to stop or reverse the degeneration of retinal neurons (i.e. photoreceptors) and retinal ganglion cells caused by glaucoma, or other degenerative or traumatic retinal diseases or injuries. O'Brien, et al., U.S. Patent Nos. 5,714,459 and 5,700,909,  
10 disclose the use of a glycoprotein, Saposin, and its derivatives for stimulating neurite outgrowth and increasing myelination. To stop or reverse degeneration of retinal neurons, LaVail et al., U.S. Patent No. 5,667,968, discloses the use of a variety of neurotrophic proteins, including  
15 brain-derived neurotrophic factor, ciliary neurotrophic factor, neurotrophin-3 or neurotrophin-4, acidic or basic fibroblast growth factors, interleukin, tumor necrosis factor- $\alpha$ , insulin-like growth factor-2 and other growth factors. Wong et al., U.S. Patent No. 5,632,984, discloses  
20 the use of interferons, especially interferon  $\alpha$ -2a, for treating the symptoms of macular degeneration by reducing hemorrhage and limiting neovascularization. Finally, Wallace et al., U.S. Patent No. 5,441,937, discloses the use of a lung-derived neurotrophic factor (NTF) to maintain the  
25 functionality of ciliary ganglion and parasympathetic neuron cells.

A key characteristic of factors derived from specific cell lines is their localization to specific cell lines or tissues; systemic treatment with these molecules would run a  
30 substantial risk of unintended, and potentially dangerous, effects in cell lines where the genes encoding these molecules are inactive. Similarly, hormones and growth factors often activate a large number of genes in many cell lines; again, non-localized application of these molecules  
35 would run a substantial risk of provoking an inappropriate,

and potentially dangerous, response.

Within the category of synthetic molecules, most of the patented compounds are immunosuppressive and disclose uses in treating inflammatory, autoimmune, and allergic responses, as  
5 discussed above. A few others are non-immunosuppressive and claim the ability to treat cellular degeneration, and in some cases promote cellular regeneration, most often in the context of their antioxidant properties.

Specifically, Tso et al., U.S. Patent No. 5,527,533,  
10 discloses the use of astaxanthin, a carotenoid antioxidant, for preventing or reducing photoreceptor damage resulting from the presence of free radicals. Similarly, Babcock et al., U.S. Patent No. 5,252,319, discloses the use of antioxidant aminosteroids for treating eye disease and  
15 injury, by increasing resistance to oxidative damage. Freeman, U.S. Patent No. 5,468,752, discloses the use of the antiviral phosphonylmethoxyalkylcytosines to reduce abnormally increased intraocular pressure.

Hamilton and Steiner disclose in U.S. Patent No.  
20 5,614,547 novel pyrrolidine carboxylate compounds which bind to the immunophilin FKBP12 and stimulate nerve growth, but which lack immunosuppressive effects. Unexpectedly, it has been discovered that these non-immunosuppressant compounds promote improvements in vision and resolve ophthalmologic  
25 disorders. Yet their novel small molecule structure and non-immunosuppressive properties differentiate them from FK506 and related immunosuppressive compounds found in the prior art.

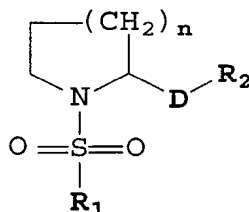
Further, these compounds may be differentiated from the  
30 non-immunosuppressive compounds used to treat vision disorders by their novel small molecule structure and their lack of general, systemic effects. Naturally occurring hormones, growth factors, cytokines, and signaling molecules are generally multifunctional and activate many genes in  
35 diverse cell lines. The present compounds do not, thus

avoiding the unexpected, and potentially dangerous, side effects of systemic use. Similarly, the present compounds also avoid the potential unexpected side effects of introducing cell line-specific molecules into other cell lines were they do not naturally occur.

### SUMMARY OF THE INVENTION

The present invention relates to the surprising discovery that a N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere may be useful for treating a vision disorder or improving vision or treating memory impairment or enhancing memory performance in an animal. Accordingly, novel compositions and methods of using a N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere are provided. A preferred feature of the compounds of the present invention is that they do not exert any significant immunosuppressive activity.

Preferred embodiments of this invention include methods and compositions containing a compound having the formula (I):



I

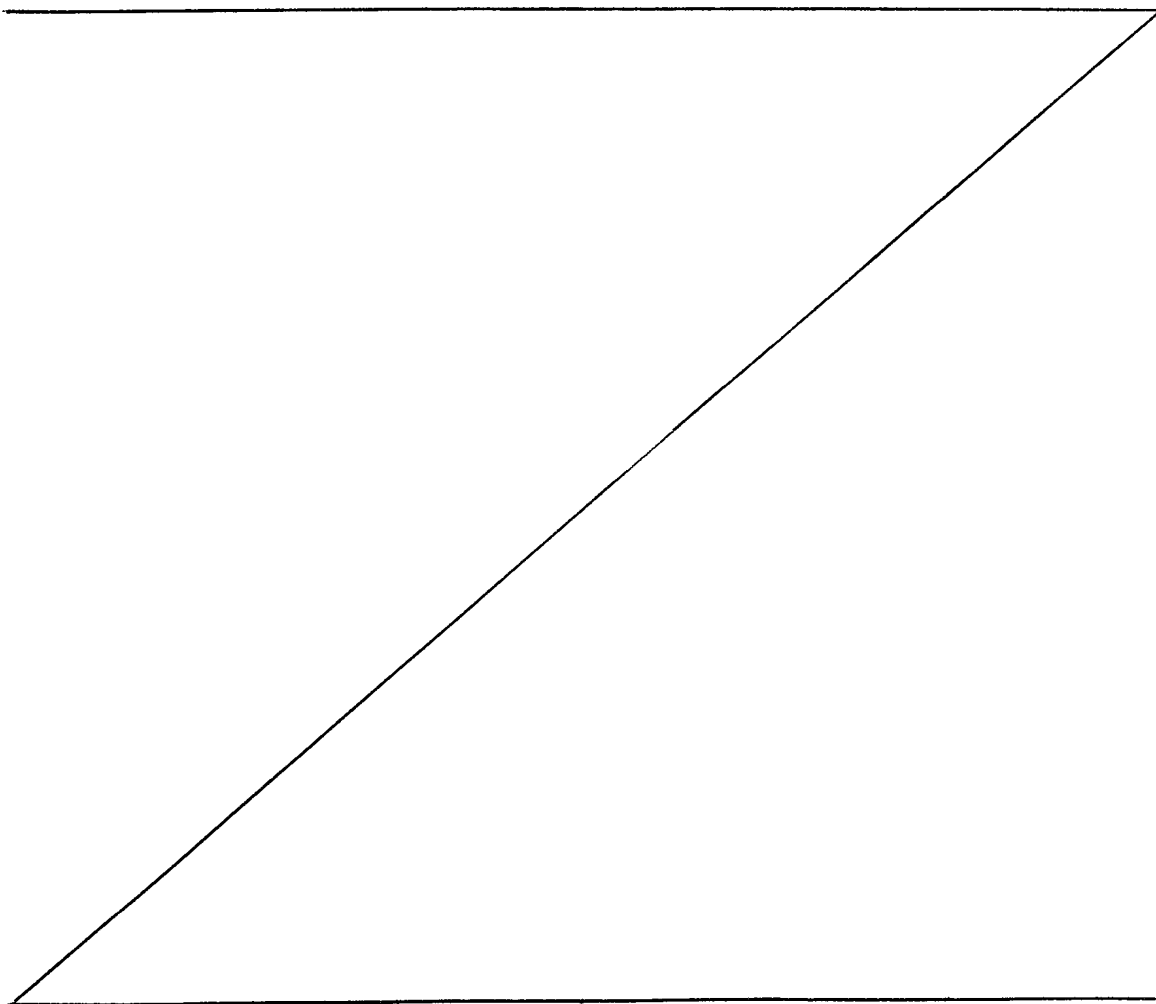
where

- n is 1-3;
- R<sub>1</sub> is selected from the group consisting of hydrogen, C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>9</sub> straight or branched chain alkenyl, aryl, heteroaryl, carbocycle, or heterocycle;
- D is a bond, or a C<sub>1</sub>-C<sub>10</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>10</sub> alkenyl or C<sub>2</sub>-C<sub>10</sub> alkynyl;
- R<sub>2</sub> is a carboxylic acid or a carboxylic acid isostere; wherein said alkyl, alkenyl, alkynyl, aryl, heteroaryl,

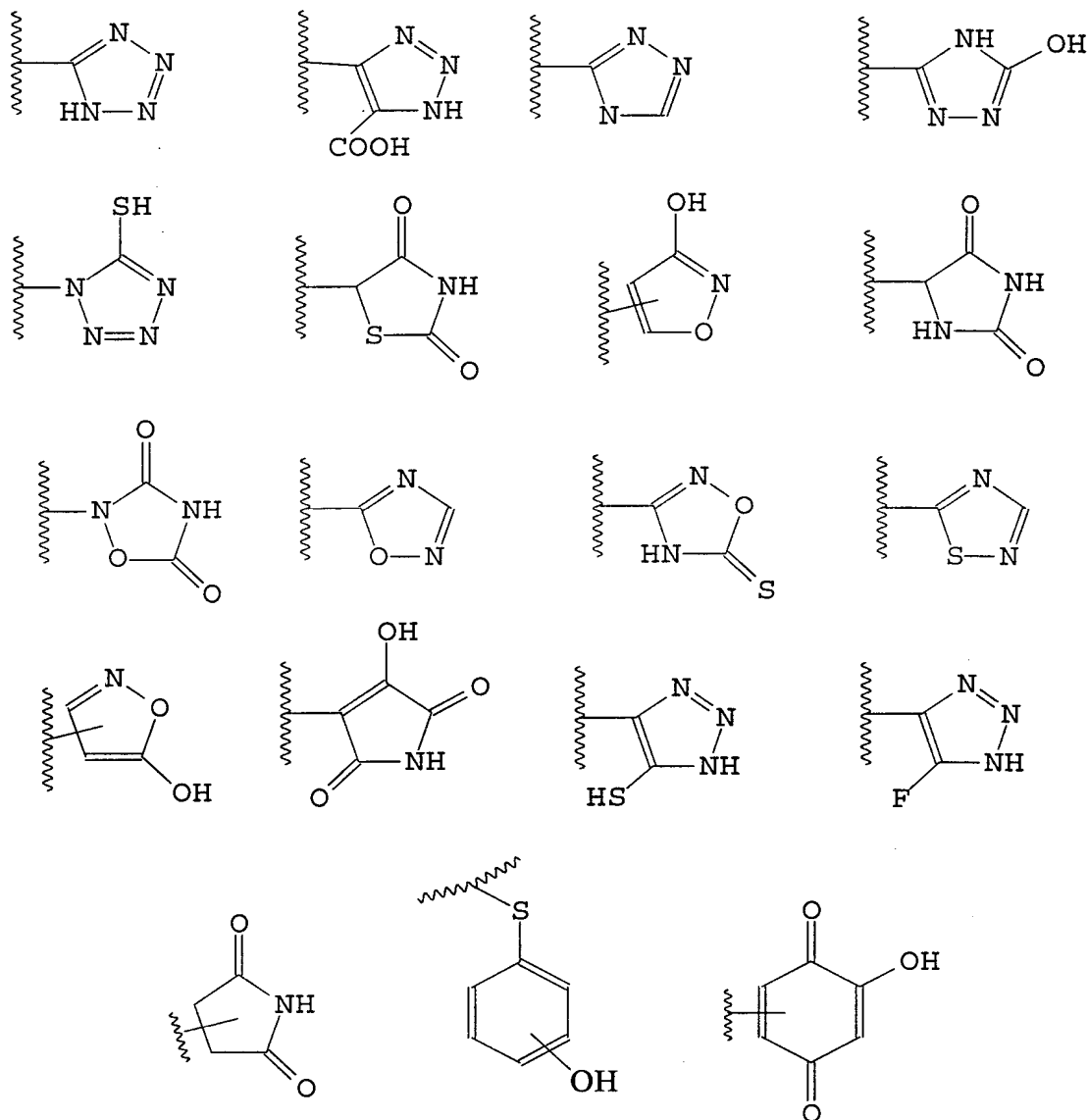
carbocycle, heterocycle, or carboxylic acid isostere is optionally substituted with one or more substituents selected from  $R^3$ , where

$R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1$ - $C_6$  straight or branched chain alkyl,  $C_2$ - $C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1$ - $C_9$  straight or branched chain alkyl or alkenyl; or a pharmaceutically acceptable salt, ester or solvate thereof.

Especially preferred embodiments of this invention are where  $R_2$  is selected from the group below:







where the atoms of said ring structure may be optionally substituted at one or more positions with  $R^3$ ,

5 where

$R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1$ - $C_6$  straight or branched chain alkyl, 10  $C_2$ - $C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, and  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1$ - $C_6$  straight or branched chain alkyl or alkenyl.

Another preferred embodiment of this invention is where  $R_2$  is selected from the group consisting of  $-\text{COOH}$ ,  $-\text{SO}_3\text{H}$ ,  $-\text{SO}_2\text{HNR}^3$ ,  $-\text{PO}_2(\text{R}^3)_2$ ,  $-\text{CN}$ ,  $-\text{PO}_3(\text{R}^3)_2$ ,  $-\text{OR}^3$ ,  $-\text{SR}^3$ ,  $-\text{NHCOR}^3$ ,  $-\text{N}(\text{R}^3)_2$ ,  $-\text{CON}(\text{R}^3)_2$ ,  $-\text{CONH}(\text{O})\text{R}^3$ ,  $-\text{CONHNHSO}_2\text{R}^3$ ,  $-\text{COHNSO}_2\text{R}^3$ , and  $-\text{CONR}^3\text{CN}$ .

5

#### **Brief Description of the Drawings**

Figure 1 A, B and C show that GPI 1046 protects retinal ganglion cells against degeneration following retinal ischemia.

10

Figure 2 shows that GPI 1046 prevents degeneration of optic nerve axons and myelin following retinal ischemia.

Figure 3 shows that GPI 1046 provides moderate protection against retinal ganglion cell death after optic nerve transection.

15

Figure 4 shows that GPI 1046 treatment duration significantly affects the process of optic nerve axonal degeneration after transection.

20

Figure 5 shows that GPI 1046 treatment produces a greater effect on optic nerve axons than ganglion cell bodies.

Figure 6 shows that GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the proximal stump.

25

Figure 7 shows that FKBP-12 immunohistochemistry labels oligodendroglia (large dark cells with fibrous processes), the cells which produce myelin, located between the fascicles of optic nerve fibers, and also some optic nerve axons.

30

Figure 8 shows GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the distal

35

stump.

Figure 9 shows that 28 day treatment with GPI 1046 treatment beginning 8 weeks after onset of streptozotocin induced diabetes decreases the extent of neovascularization in the inner and outer retina and protects neurons in the inner nuclear layer (INL) and ganglion cell layer (GCL) from degeneration.

10                    **DETAILED DESCRIPTION OF THE INVENTION**

**Definitions**

                    "Eye" refers to the anatomical structure responsible for vision in humans and other animals, and encompasses the following anatomical structures, without limitation: lens, vitreous body, ciliary body, posterior chamber, anterior chamber, pupil, cornea, iris, canal of Schlemm, zonules of Zinn, limbus, conjunctiva, choroid, retina, central vessels of the retina, optic nerve, fovea centralis, macula lutea, and sclera.

20                    "Alkyl" means a branched or unbranched saturated hydrocarbon chain comprising a designated number of carbon atoms. For example, C<sub>1</sub>-C<sub>6</sub> straight or branched alkyl hydrocarbon chain contains 1 to 6 carbon atoms, and includes but is not limited to substituents such as methyl, ethyl, propyl, iso-propyl, butyl, iso-butyl, tert-butyl, n-pentyl, n-hexyl, and the like. It is also contemplated as within the scope of the present invention that "alkyl" may also refer to a hydrocarbon chain wherein any of the carbon atoms of said alkyl are optionally replaced with O, NH, S, or SO<sub>2</sub>. For example, carbon 2 of n-pentyl can be replaced with O to form propyloxymethyl.

                    "Alkenyl" means a branched or unbranched unsaturated hydrocarbon chain comprising a designated number of carbon atoms. For example, C<sub>2</sub>-C<sub>6</sub> straight or branched alkenyl hydrocarbon chain contains 2 to 6 carbon atoms having at

least one double bond, and includes but is not limited to substituents such as ethenyl, propenyl, iso-propenyl, butenyl, iso-butenyl, tert-butenyl, n-pentenyl, n-hexenyl, and the like. It is also contemplated as within the scope of  
5 the present invention that "alkenyl" may also refer to an unsaturated hydrocarbon chain wherein any of the carbon atoms of said alkenyl are optionally replaced with O, NH, S, or SO<sub>2</sub>. For example, carbon 2 of 4-pentene can be replaced with O to form (2-propene)oxymethyl.

10 "Alkoxy" means the group -OR wherein R is alkyl as herein defined. Preferably, R is a branched or unbranched saturated hydrocarbon chain containing 1 to 6 carbon atoms.

Aryl, heteroaryl, carbocycle, or heterocycle means a cyclic or fused cyclic ring and includes a mono-, bi- or  
15 tricyclic, carbo- or heterocyclic ring, wherein the ring is either unsubstituted or substituted in one or more position(s) with hydrogen, hydroxy, carbonyl, amino, amido, cyano, isocyano, nitro, nitroso, nitrilo, isonitrilo, imino, azo, diazo, sulfonyl, sulfhydryl, sulfoxy, thio,  
20 thiocarbonyl, thiocyano, formanilido, thioformamido, sulfhydryl, halo, haloalkyl, trifluoromethyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, alkylamino, aminoalkyl, thioalkyl, alkylthio, C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>6</sub> straight or branched chain alkenyl or  
25 alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or CO<sub>2</sub>R<sup>4</sup> where R<sup>4</sup> is hydrogen or C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl and carbocyclic and heterocyclic moieties. Carbocyclic moieties include alicyclic and aromatic structures; wherein the individual ring sizes are 5-8 members; wherein the  
30 heterocyclic ring contains 1-4 heteroatom(s) selected from the group consisting of O, N, or S; wherein aromatic or tertiary alkyl amines are optionally oxidized to a corresponding N-oxide. Examples of useful alkyl groups include, without limitation, methyl, ethyl, propyl,  
35 isopropyl, butyl, tert-butyl, n-pentyl, 2-methyl pentyl and

the like. Examples of useful carbocyclic and heterocyclic moieties include, without limitation, phenyl, benzyl, naphthyl, indenyl, azulenyl, fluorenyl, anthracenyl, indolyl, isoindolyl, indolinyl, cyclohexyl, benzofuranyl, 5 benzothiophenyl, indazolyl, benzimidazolyl, benzthiazolyl, tetrahydrofuranyl, tetrahydropyranyl, pyridyl, pyrrolyl, pyrrolidinyl, pyridinyl, pyrimidinyl, purinyl, quinolinyl, isoquinolinyl, tetrahydroquinolinyl, quinoliziny, furyl, thiophenyl, imidazolyl, oxazolyl, benzoxazolyl, thiazolyl, 10 isoxazolyl, isotriazolyl, oxadiazolyl, triazolyl, thiadiazolyl, pyridazinyl, pyrimidinyl, pyrazinyl, triazinyl, trithianyl, indoliziny, pyrazolyl, pyrazolinyl, pyrazolidinyl, thienyl, tetrahydroisoquinolinyl, cinnolinyl, phthalazinyl, quinazolinyl, quinoxalinyl, naphthyridinyl, 15 pteridinyl, carbazolyl, acridinyl, phenazinyl, phenothiazinyl, phenoxazinyl, and adamantyl.

"Halo" means at least one fluoro, chloro, bromo, or iodo moiety.

The term "pharmaceutically acceptable salt, ester, or 20 solvate" refers to salt, ester, or solvates of the subject compounds which possess the desired pharmacological activity and which are neither biologically nor otherwise undesirable. The salt, ester, or solvates can be formed with inorganic or organic acids such as acetate, adipate, alginate, aspartate, 25 benzoate, benzenesulfonate, bisulfate, butyrate, citrate, camphorate, camphorsulfonate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, fumarate, glucoheptanoate, gluconate, glycerophosphate, hemisulfate, heptanoate, hexanoate, hydrochloride hydrobromide, 30 hydroiodide, 2-hydroxyethanesulfonate, lactate, maleate, methanesulfonate, naphthylate, 2-naphthalenesulfonate, nicotinate, oxalate, sulfate, thiocyanate, tosylate and undecanoate. Base salt, ester, or solvates include ammonium salts, alkali metal salts such as lithium, sodium and 35 potassium salts, alkaline earth metal salts such as calcium

and magnesium salts, salt with organic bases such as dicyclohexylamine salts, N-methyl-D-glucamine, and salts with amino acids such as arginine, lysine, and so forth. Also, the basic nitrogen-containing groups can be quarternized with  
5 such agents as: 1) lower alkyl halides, such as methyl, ethyl, propyl, and butyl chloride, bromides and iodides; 2) dialkyl sulfates like dimethyl, diethyl, dibutyl and diamyl sulfates; 3) long chain alkyls such as decyl, lauryl, myristyl and stearyl substituted with one or more halide such  
10 as chloride, bromide and iodide; and 4) aryl or aralkyl halides like benzyl and phenethyl bromide and others.

The compounds of this invention may possess at least one asymmetric center and thus can be produced as mixtures of stereoisomers or as individual enantiomers or diastereomers.  
15 The individual stereoisomers may be obtained by using an optically active starting material, by resolving a racemic or non-racemic mixture of an intermediate at some appropriate stage of the synthesis, or by resolution of the compound of formula (I). It is understood that the individual  
20 stereoisomers as well as mixtures (racemic and non-racemic) of stereoisomers are encompassed by the scope of the present invention. The S-stereoisomer at atom 1 of formula I is a most preferred embodiment of the invention.

"Stereoisomers" are isomers that differ only in the way  
25 the atoms are arranged in space.

"Isomers" are different compounds that have the same molecular formula and includes cyclic isomers such as (iso)indole and other isomeric forms of cyclic moieties.

"Enantiomers" are a pair of stereoisomers that are non-  
30 superimposable mirror images of each other.

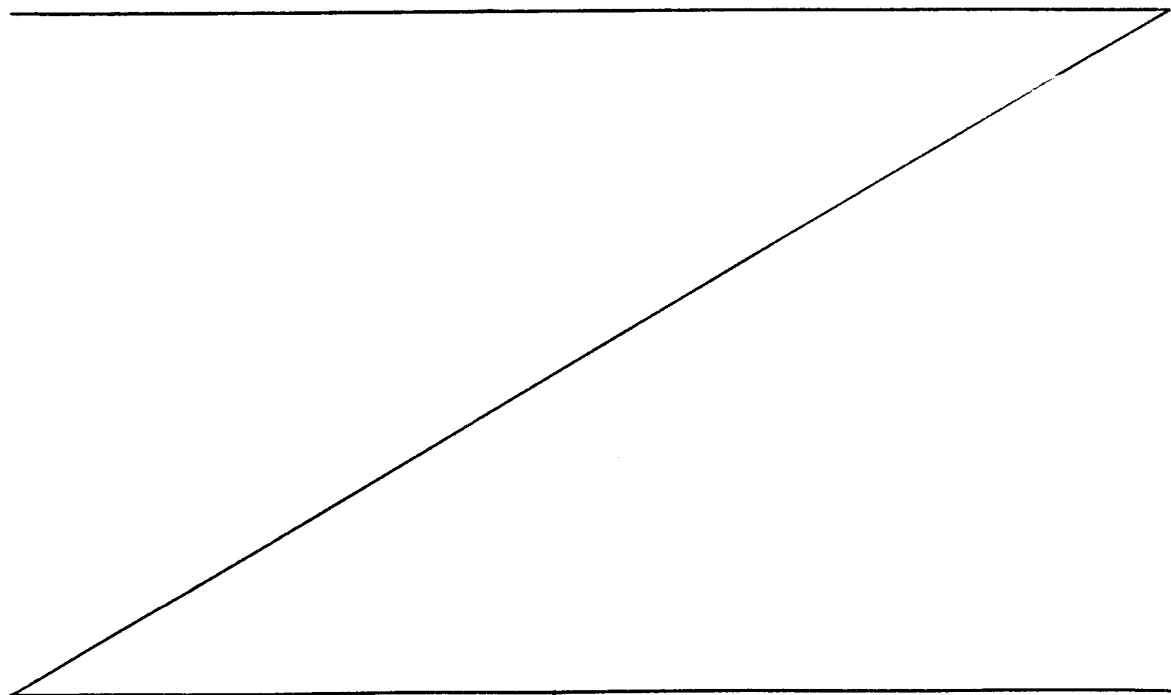
"Diastereoisomers" are stereoisomers which are not mirror images of each other.

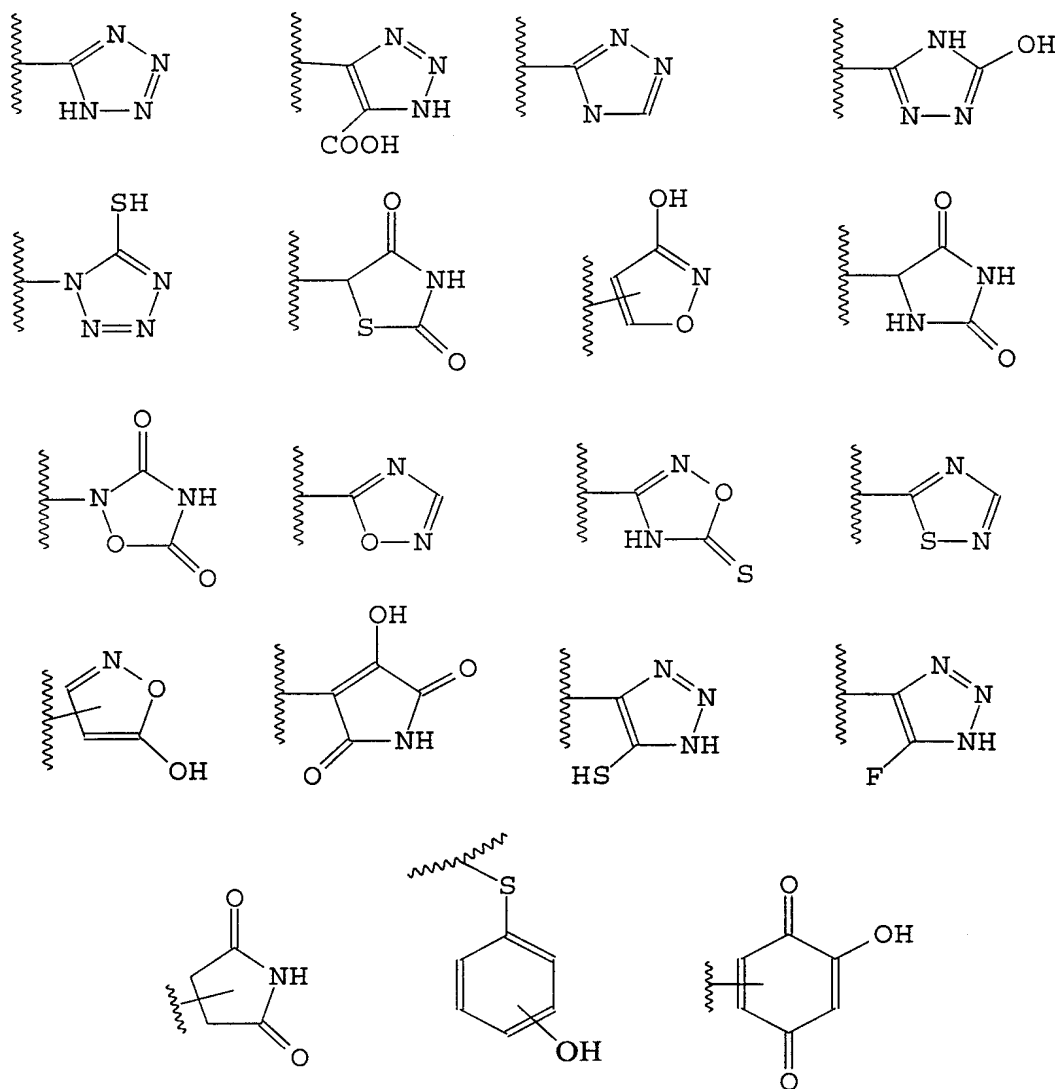
"Racemic mixture" means a mixture containing equal parts of individual enantiomers. "Non-racemic mixture" is a  
35 mixture containing unequal parts of individual enantiomers or

stereoisomers.

"Isosteres" are different compounds that have different molecular formulae but exhibit the same or similar properties. For example, tetrazole is an isostere of  
5 carboxylic acid because it mimics the properties of carboxylic acid even though they both have very different molecular formulae. Tetrazole is one of many possible isosteric replacements for carboxylic acid. Other carboxylic acid isosteres contemplated by the present invention include  
10 -COOH, -SO<sub>3</sub>H, -SO<sub>2</sub>HNR<sup>3</sup>, -PO<sub>2</sub>(R<sup>3</sup>)<sub>2</sub>, -CN, -PO<sub>3</sub>(R<sup>3</sup>)<sub>2</sub>, -OR<sup>3</sup>, -SR<sup>3</sup>, -NHCOR<sup>3</sup>, -N(R<sup>3</sup>)<sub>2</sub>, -CON(R<sup>3</sup>)<sub>2</sub>, -CONH(O)R<sup>3</sup>, -CONHNHSO<sub>2</sub>R<sup>3</sup>, -COHNSO<sub>2</sub>R<sup>3</sup>, and -CONR<sup>3</sup>CN.

In addition, carboxylic acid isosteres can include 5-7 membered carbocycles or heterocycles containing any  
15 combination of CH<sub>2</sub>, O, S, or N in any chemically stable oxidation state, where any of the atoms of said ring structure are optionally substituted in one or more positions. The following structures are non-limiting examples of preferred carbocyclic and heterocyclic isosteres  
20 contemplated by this invention.





where the atoms of said ring structure may be optionally substituted at one or more positions with  $R^3$ . The present invention contemplates that when chemical substituents are added to a carboxylic isostere then the inventive compound retains the properties of a carboxylic isostere. The present invention contemplates that when a carboxylic isostere is optionally substituted with one or more moieties selected from  $R^3$ , then the substitution cannot eliminate the carboxylic acid isosteric properties of the inventive compound. The present invention contemplates that the placement of one or more  $R^3$  substituents upon a carbocyclic



or heterocyclic carboxylic acid isostere shall not be at an atom(s) which maintains or is integral to the carboxylic acid isosteric properties of the inventive compound if such substituent(s) would destroy the carboxylic acid isosteric properties of the inventive compound.

Other carboxylic acid isosteres not specifically exemplified or described in this specification are also contemplated by the present invention.

The term "treatment" as used herein covers any treatment of a disease and/or condition in an animal, particularly a human, and includes:

(i) preventing a disease and/or condition from occurring in a subject which may be predisposed to the disease and/or condition but has not yet been diagnosed as having it;

(ii) inhibiting the disease and/or condition, i.e., arresting its development; or

(iii) relieving the disease and/or condition, i.e., causing regression of the disease and/or condition.

The system used in naming the compounds of the present invention is shown below, using a compound of formula I as an example.

A compound of the present invention, especially formula I, wherein n is 1, D is a bond, R<sub>1</sub> is phenylmethyl, and R<sub>2</sub> is -CN, is named (2S)-1-(phenylmethyl) sulfonyl-2-pyrrolidine carbonitrile.

"Enhancing memory performance" refers to improving or increasing the mental faculty by which to register, retain or recall past experiences, knowledge, ideas, sensations, thoughts or impressions.

"Memory impairment" refers to a diminished mental registration, retention or recall of past experiences, knowledge, ideas, sensations, thoughts or impressions. Memory impairment may affect short and long-term information retention, facility with spatial relationships, memory

(rehearsal) strategies, and verbal retrieval and production. Common causes of memory impairment are age, severe head trauma, brain anoxia or ischemia, alcoholic-nutritional diseases, and drug intoxications. Examples of memory  
5 impairment include, without limitation, benign forgetfulness, amnesia and any disorder in which memory deficiency is present, such as Korsakoff's amnesic psychosis, dementia and learning disorders.

"Neopsic factors" or "neopsics" refers to compounds  
10 useful in treating vision loss, preventing vision degeneration, or promoting vision regeneration.

"Neopsis" refers to the process of treating vision loss, preventing vision degeneration, or promoting vision regeneration.

15 "Ophthalmological" refers to anything about or concerning the eye, without limitation, and is used interchangeably with "ocular," "ophthalmic," "ophthalmologic," and other such terms, without limitation.

"Preventing vision degeneration" refers to the ability  
20 to prevent degeneration of vision in patients newly diagnosed as having a degenerative disease affecting vision, or at risk of developing a new degenerative disease affecting vision, and for preventing further degeneration of vision in patients who are already suffering from or have symptoms of a  
25 degenerative disease affecting vision.

"Promoting vision regeneration" refers to maintaining, improving, stimulating or accelerating recovery of, or revitalizing one or more components of the visual system in a manner which improves or enhances vision, either in the  
30 presence or absence of any ophthalmologic disorder, disease, or injury.

"Treating" refers to:

(i) preventing a disease and/or condition from occurring in a subject which may be predisposed to the  
35 disease and/or condition but has not yet been diagnosed as

having it;

(ii) inhibiting the disease and/or condition, i.e., arresting its development; or

(iii) relieving the disease and/or condition, i.e.,  
5 causing regression of the disease and/or condition.

"Vision" refers to the ability of humans and other animals to process images, and is used interchangeably with "sight", "seeing", and other such terms, without limitation.

"Vision disorder" refers to any disorder that affects or  
10 involves vision, including without limitation visual impairment, orbital disorders, disorders of the lacrimal apparatus, disorders of the eyelids, disorders of the conjunctiva, disorders of the cornea, cataracts, disorders of the uveal tract, disorders of the retina, disorders of the  
15 optic nerve or visual pathways, free radical induced eye disorders and diseases, immunologically-mediated eye disorders and diseases, eye injuries, and symptoms and complications of eye disease, eye disorder, or eye injury.

"Visual impairment" refers to any dysfunction in vision  
20 including without limitation disturbances or diminution in vision (e.g., binocular, central, peripheral, scotopic), visual acuity for objects near and far, visual field, ocular motility, color perception, adaptation to light and dark, accommodation, refraction, and lacrimation. See Physician's  
25 Desk Reference (PDR) for Ophthalmology, 16<sup>th</sup> Edition, 6:47 (1988).

### **Methods of the Present Invention**

The present invention relates to a method of treating a  
30 vision disorder, improving vision, treating memory impairment, or enhancing memory performance in an animal, which comprises administering to said animal an effective amount of a derivative.

The inventive methods are particularly useful for  
35 treating various eye disorders including but not limited to

visual disorders, diseases, injuries, and complications, genetic disorders; disorders associated with aging or degenerative vision diseases; vision disorders correlating to physical injury to the eye, head, or other parts of the body  
5 resulting from external forces; vision disorders resulting from environmental factors; vision disorders resulting from a broad range of diseases; and combinations of any of the above.

In particular, the compositions and methods of the  
10 present invention are useful for improving vision, or correcting, treating, or preventing visual (ocular) impairment or dysfunction of the visual system, including permanent and temporary visual impairment, without limitation. The present invention is also useful in  
15 preventing and treating ophthalmologic diseases and disorders, treating damaged and injured eyes, and preventing and treating diseases, disorders, and injuries which result in vision deficiency, vision loss, or reduced capacity to see or process images, and the symptoms and complications  
20 resulting from same. The eye diseases and disorders which may be treated or prevented by the compositions and methods of the present invention are not limited with regard to the cause of said diseases or disorders. Accordingly, said compositions and methods are applicable whether the disease  
25 or disorder is caused by genetic or environmental factors, as well as any other influences. The compositions and methods of the present invention are particularly useful for eye problems or vision loss or deficiency associated with all of the following, without limitation: aging, cellular or  
30 physiological degeneration, central nervous system or neurological disorder, vascular defects, muscular defects, and exposure to adverse environmental conditions or substances.

The compositions and methods of the present invention  
35 are particularly useful in correcting, treating, or improving

visual impairment, without limitation. Visual impairment in varying degrees occurs in the presence of a deviation from normal in one or more functions of the eye, including (1) visual acuity for objects at distance and near; (2) visual  
5 fields; and (3) ocular motility without diplopia. See *Physicians' Desk Reference (PDR) for Ophthalmology, 16th Edition, 6:47 (1988)*. Vision is imperfect without the coordinated function of all three. *Id.*

Said compositions and methods of use are also useful in  
10 correcting, treating, or improving other ocular functions including, without limitation, color perception, adaptation to light and dark, accommodation, metamorphopsia, and binocular vision. The compositions and methods of use are particularly useful in treating, correcting, or preventing  
15 ocular disturbances including, without limitation, paresis of accommodation, iridoplegia, entropion, ectropion, epiphora, lagophthalmos, scarring, vitreous opacities, non-reactive pupil, light scattering disturbances of the cornea or other media, and permanent deformities of the orbit.

20 The compositions and methods of use of the present invention are also highly useful in improving vision and treating vision loss. Vision loss ranging from slight loss to absolute loss may be treated or prevented using said compositions and methods of use. Vision may be improved by  
25 the treatment of eye disorders, diseases, and injuries using the compositions and methods of the invention. However, improvements in vision using the compositions and methods of use are not so limited, and may occur in the absence of any such disorder, disease, or injury.

30 The compositions and methods of the present invention are also useful in the treatment or prevention of the following non-limiting exemplary diseases and disorders, and symptoms and complications resulting therefrom.

Vision disorders include but are not limited to the  
35 following:

visual impairment, such as diminished visual acuity for objects near and far, visual fields, and ocular motility;

orbital disorders, such as orbital cellulitis, periorbital cellulitis, cavernous sinus thrombosis, and  
5 exophthalmos (proptosis);

disorders of the lacrimal apparatus, such as dacryostenosis, congenital dacryostenosis, and dacryocystitis (acute or chronic);

disorders of the eyelids, such as lid edema,  
10 blepharitis, ptosis, Bell's palsy, blepharospasm, hordeolum (stye), external hordeolum, internal hordeolum (meibomian stye), chalazion, entropion (inversion of the eyelid), ectropion (eversion of the eyelid), tumors (benign and malignant), xanthelasma, basal cell carcinoma, squamous cell  
15 carcinoma, meibomian gland carcinoma, and melanoma;

disorders of the conjunctiva, such as pinguecula, pterygium, and other neoplasms, acute conjunctivitis, chronic conjunctivitis, adult gonococcal conjunctivitis, neonatal conjunctivitis, trachoma (granular conjunctivitis or Egyptian  
20 ophthalmia), inclusion conjunctivitis (inclusion blenorrhea or swimming pool conjunctivitis), neonatal inclusion conjunctivitis, adult inclusion conjunctivitis, vernal keratoconjunctivitis, keratoconjunctivitis sicca (keratitis sicca or dry eye syndrome), episcleritis, scleritis,  
25 cicatricial pemphigoid (ocular cicatricial pemphigoid or benign mucous membrane pemphigoid), and subconjunctival hemorrhage;

disorders of the cornea, such as superficial punctate keratitis, corneal ulcer, indolent ulcer, recurrent corneal  
30 erosion, corneal epithelial basement membrane dystrophy, corneal endothelial cell dystrophy, herpes simplex keratitis (herpes simplex keratoconjunctivitis), dendritic keratitis, disciform keratitis, ophthalmic herpes zoster, phlyctenular keratoconjunctivitis (phlyctenular or eczematous  
35 conjunctivitis), interstitial keratitis (parenchymatous

keratitis), peripheral ulcerative keratitis (marginal keratolysis or peripheral rheumatoid ulceration), keratomalacia (xerotic keratitis), xerophthalmia, keratoconus, bullous keratopathy;

5 cataracts, including developmental or congenital cataracts, juvenile or adult cataracts, nuclear cataract, posterior subcapsular cataracts;

disorders of the uveal tract, such as uveitis (inflammation of the uveal tract or retina), anterior  
10 uveitis, intermediate uveitis, posterior uveitis, iritis, cyclitis, choroiditis, ankylosing spondylitis, Reiter's syndrome, pars planitis, toxoplasmosis, cytomegalovirus (CMV), acute retinal necrosis, toxocariasis, birdshot choroidopathy, histoplasmosis (presumed ocular histoplasmosis  
15 syndrome), Behcet's syndrome, sympathetic ophthalmia, Vogt-Koyanagi-Harada syndrome, sarcoidosis, reticulum cell sarcoma, large cell lymphoma, syphilis, tuberculosis, juvenile rheumatoid arthritis, endophthalmitis, and malignant melanoma of the choroid;

20 disorders of the retina, such as vascular retinopathies (e.g., arteriosclerotic retinopathy and hypertensive retinopathy), central and branch retinal artery occlusion, central and branch retinal vein occlusion, diabetic retinopathy (e.g., proliferative retinopathy and non-  
25 proliferative retinopathy), macular degeneration of the aged (age-related macular degeneration or senile macular degeneration), neovascular macular degeneration, retinal detachment, retinitis pigmentosa, retinal photic injury, retinal ischemia-induced eye injury, and glaucoma (e.g.,  
30 primary glaucoma, chronic open-angle glaucoma, acute or chronic angle-closure, congenital (infantile) glaucoma, secondary glaucoma, and absolute glaucoma);

disorders of the optic nerve or visual pathways, such as papilledema (choked disk), papillitis (optic neuritis),  
35 retrobulbar neuritis, ischemic optic neuropathy, toxic

amblyopia, optic atrophy, higher visual pathway lesions, disorders of ocular motility (e.g., third cranial nerve palsies, fourth cranial nerve palsies, sixth cranial nerve palsies, internuclear ophthalmoplegia, and gaze palsies);

5 free radical induced eye disorders and diseases; and immunologically-mediated eye disorders and diseases, such as Graves' ophthalmopathy, conical cornea, dystrophia epithelialis corneae, corneal leukoma, ocular pemphigus, Mooren's ulcer, scleritis, and sarcoidosis (See *The Merck*  
10 *Manual*, Sixteenth Edition, 217:2365-2397 (1992) and *The Eye Book*, Cassel, Billig, and Randall, The Johns Hopkins University Press (1998)).

The compositions and methods of the present invention are also useful in the treatment of the following non-  
15 limiting eye injuries, and symptoms and complications resulting therefrom: conjunctival and corneal foreign body injuries, corneal abrasion, intraocular foreign body injuries, lacerations, lid lacerations, contusions, lid contusions (black eye), trauma to the globe, laceration of  
20 the iris, cataract, dislocated lens, glaucoma, vitreous hemorrhage, orbital-floor fractures, retinal hemorrhage or detachment, and rupture of the eyeball, anterior chamber hemorrhage (traumatic hyphema), burns, eyelid burns, chemical burns, chemical burns of the cornea and conjunctiva, and  
25 ultraviolet light burns (sunburn). See *The Merck Manual*, Sixteenth Edition, 217:2364-2365 (1992).

The compositions and methods of the present invention are also useful in treating and/or preventing the following non-limiting exemplary symptoms and complications of eye  
30 disease, eye disorder or eye injury: subconjunctival hemorrhages, vitreous hemorrhages, retinal hemorrhages, floaters, retinal detachments, photophobia, ocular pain, scotomas (negative and positive), errors of refraction, emmetropia, ametropia, hyperopia (farsightedness), myopia  
35 (nearsightedness), astigmatism, anisometropia, aniseikonia,



presbyopia, bleeding, recurrent bleeding, sympathetic ophthalmia, inflammation, swelling, redness of the eye, irritation of the eye, corneal ulceration and scarring, iridocyclitis, perforation of the globe, lid deformities, 5 exophthalmos, impaired mobility of the eye, lid swelling, chemosis, loss of vision, including partial or total blindness, optic neuritis, fever, malaise, thrombophlebitis, cavernous sinus thrombosis, panophthalmitis, infection of the meninges and brain, papilledema, severe cerebral symptoms 10 (headache, decreased level of consciousness, and convulsions), cranial nerve palsies, epiphora (chronic or persistent tearing), copious reflux of mucus or pus, follicular subconjunctival hyperplasia, corneal vascularization, cicatrization of the conjunctiva, cornea, 15 and lids, pannus, hypopyon, lagophthalmos, phlyctenules, rubeosis iridis, bitemporal hemianopia, and homonymous hemianopia. See *The Merck Manual, Sixteenth Edition*, 217:2362-2363 (1992).

The derivative may be administered in combination with 20 an effective amount of one or more factor(s) useful in treating vision disorder, improving vision, treating memory impairment, or enhancing memory performance.

In a preferred embodiment, the factor(s) to be combined with the derivative is/are selected from the group consisting 25 of immunosuppressants for treating autoimmune, inflammatory, and immunologically-mediated disorders; wound healing agents for treating wounds resulting from injury or surgery; antiglaucomatous medications for treating abnormally elevated intraocular pressure; neurotrophic factors and growth factors 30 for treating neurodegenerative disorders or stimulating neurite outgrowth; compounds effective in limiting or preventing hemorrhage or neovascularization for treating macular degeneration; and antioxidants for treating oxidative damage to eye tissues.

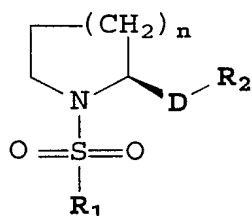
**Pharmaceutical Compositions of the Present Invention**

The present invention also relates to a pharmaceutical composition comprising:

- (i) an effective amount of a derivative for treating a vision disorder, improving vision, treating memory impairment, or enhancing memory performance in an animal; and

- (ii) a pharmaceutically acceptable carrier.

The derivative may be administered in combination with an effective amount of one or more factor(s) useful in treating vision disorders, improving vision, treating memory impairment, or enhancing memory performance.

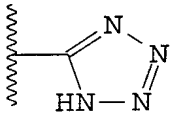
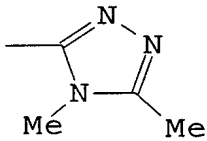
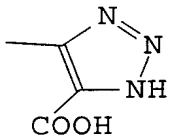
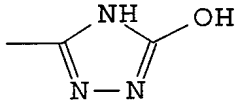
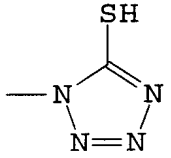
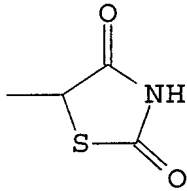
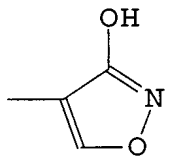
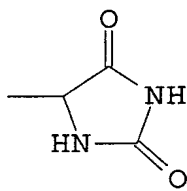
**Table A**

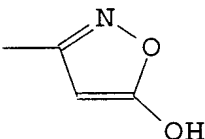
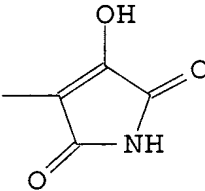
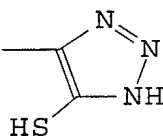
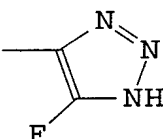
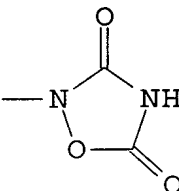
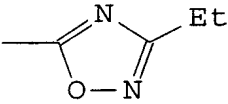
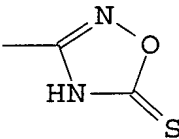
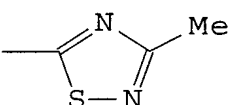
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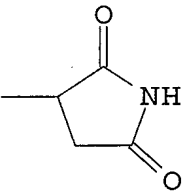
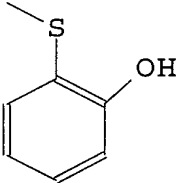
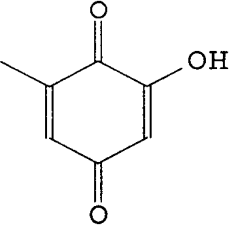
| No. | n | D               | R2                             | R1                     |
|-----|---|-----------------|--------------------------------|------------------------|
| 1   | 1 | bond            | COOH                           | Benzyl                 |
| 2   | 1 | bond            | COOH                           | $\alpha$ -MethylBenzyl |
| 20  | 3 | bond            | COOH                           | 4-MethylBenzyl         |
| 4   | 1 | bond            | Tetrazole                      | Benzyl                 |
| 5   | 1 | bond            | SO <sub>3</sub> H              | $\alpha$ -MethylBenzyl |
| 6   | 1 | CH <sub>2</sub> | COOH                           | 4-MethylBenzyl         |
| 7   | 1 | bond            | SO <sub>2</sub> HNMe           | Benzyl                 |
| 25  | 8 | bond            | CN                             | $\alpha$ -MethylBenzyl |
| 9   | 1 | bond            | PO <sub>3</sub> H <sub>2</sub> | 4-MethylBenzyl         |
| 10  | 2 | bond            | COOH                           | Benzyl                 |
| 11  | 2 | bond            | COOH                           | $\alpha$ -MethylBenzyl |
| 12  | 2 | bond            | COOH                           | 4-MethylBenzyl         |

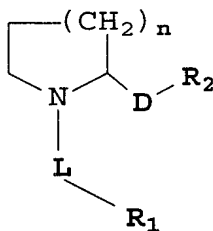
|    | No. | n | D                               | R2                                | R1                     |
|----|-----|---|---------------------------------|-----------------------------------|------------------------|
|    | 13  | 2 | bond                            | COOH                              | 3,4,5-trimethoxyphenyl |
|    | 14  | 2 | bond                            | COOH                              | Cyclohexyl             |
|    | 15  | 2 | bond                            | PO <sub>2</sub> HEt               | i-propyl               |
|    | 16  | 2 | bond                            | PO <sub>3</sub> HPropyl           | ethyl                  |
| 5  | 17  | 2 | bond                            | PO <sub>3</sub> (Et) <sub>2</sub> | Methyl                 |
|    | 18  | 2 | bond                            | OMe                               | tert-butyl             |
|    | 19  | 2 | bond                            | OEt                               | n-pentyl               |
|    | 20  | 2 | bond                            | OPropyl                           | n-hexyl                |
|    | 21  | 1 | bond                            | OButyl                            | Cyclohexyl             |
| 10 | 22  | 1 | bond                            | OPentyl                           | cyclopentyl            |
|    | 23  | 1 | bond                            | OHexyl                            | n-heptyl               |
|    | 24  | 1 | bond                            | SMe                               | n-octyl                |
|    | 25  | 1 | bond                            | SEt                               | n-nonyl                |
|    | 26  | 2 | bond                            | SPropyl                           | 2-indolyl              |
| 15 | 27  | 2 | bond                            | SButyl                            | 2-furyl                |
|    | 28  | 2 | bond                            | NHCOMe                            | 2-thiazolyl            |
|    | 29  | 2 | bond                            | NHCOEt                            | 2-thienyl              |
|    | 30  | 1 | CH <sub>2</sub>                 | N(Me) <sub>2</sub>                | 2-pyridyl              |
|    | 31  | 1 | (CH <sub>2</sub> ) <sub>2</sub> | N(Me)Et                           | benzyl                 |
| 20 | 32  | 1 | (CH <sub>2</sub> ) <sub>3</sub> | CON(Me) <sub>2</sub>              | benzyl                 |
|    | 33  | 1 | (CH <sub>2</sub> ) <sub>4</sub> | CONHMe                            | benzyl                 |
|    | 34  | 1 | (CH <sub>2</sub> ) <sub>5</sub> | CONHEt                            | benzyl                 |
|    | 35  | 1 | (CH <sub>2</sub> ) <sub>6</sub> | CONHPropyl                        | 1,1-dimethylpropyl     |
|    | 36  | 1 | bond                            | CONH(O)Me                         | Benzyl                 |
| 25 | 37  | 1 | bond                            | CONH(O)Et                         | α-Methylphenyl         |
|    | 38  | 1 | bond                            | CONH(O)Propyl                     | 4-Methylphenyl         |
|    | 39  | 2 | bond                            | COOH                              | Benzyl                 |
|    | 40  | 2 | bond                            | COOH                              | α-Methylphenyl         |
|    | 41  | 2 | bond                            | COOH                              | 4-Methylphenyl         |
| 30 | 42  | 1 | CH <sub>2</sub>                 | COOH                              | benzyl                 |

|    | No. | n | D                                | R2                       | R1             |
|----|-----|---|----------------------------------|--------------------------|----------------|
|    | 43  | 1 | (CH <sub>2</sub> ) <sub>2</sub>  | COOH                     | benzyl         |
|    | 44  | 1 | (CH <sub>2</sub> ) <sub>3</sub>  | COOH                     | benzyl         |
|    | 45  | 1 | (CH <sub>2</sub> ) <sub>4</sub>  | COOH                     | benzyl         |
|    | 46  | 1 | (CH <sub>2</sub> ) <sub>5</sub>  | COOH                     | benzyl         |
| 5  | 47  | 1 | (CH <sub>2</sub> ) <sub>6</sub>  | COOH                     | benzyl         |
|    | 48  | 1 | (CH <sub>2</sub> ) <sub>7</sub>  | COOH                     | benzyl         |
|    | 49  | 1 | (CH <sub>2</sub> ) <sub>8</sub>  | COOH                     | benzyl         |
|    | 50  | 1 | (CH <sub>2</sub> ) <sub>9</sub>  | COOH                     | benzyl         |
|    | 51  | 1 | (CH <sub>2</sub> ) <sub>10</sub> | COOH                     | benzyl         |
| 10 | 52  | 1 | C <sub>2</sub> H <sub>2</sub>    | COOH                     | benzyl         |
|    | 53  | 1 | 2-OH, Et                         | COOH                     | benzyl         |
|    | 54  | 1 | 2butylene                        | COOH                     | benzyl         |
|    | 55  | 1 | i-Pro                            | COOH                     | benzyl         |
|    | 56  | 1 | tert-Bu                          | COOH                     | benzyl         |
| 15 | 57  | 1 | 2-nitroHexyl                     | COOH                     | benzyl         |
|    | 58  | 3 | (CH <sub>2</sub> ) <sub>2</sub>  | CN                       | benzyl         |
|    | 59  | 1 | (CH <sub>2</sub> ) <sub>3</sub>  | CN                       | benzyl         |
|    | 60  | 3 | bond                             | CONHNHSO <sub>2</sub> Me | Benzyl         |
|    | 61  | 3 | bond                             | CONHNHSO <sub>2</sub> Et | α-Methylphenyl |
| 20 | 62  | 3 | bond                             | CONHSO <sub>2</sub> Me   | 4-Methylphenyl |
|    | 63  | 2 | bond                             | CONHNHSO <sub>2</sub> Et | Phenyl         |
|    | 64  | 2 | bond                             | CON(Me)CN                | α-Methylphenyl |
|    | 65  | 2 | bond                             | CON(Et)CN                | 4-Methylphenyl |
|    | 66  | 1 | (CH <sub>2</sub> ) <sub>2</sub>  | COOH                     | methyl         |
| 25 | 67  | 1 | (CH <sub>2</sub> ) <sub>3</sub>  | COOH                     | ethyl          |
|    | 68  | 1 | (CH <sub>2</sub> ) <sub>4</sub>  | COOH                     | n-propyl       |
|    | 69  | 1 | (CH <sub>2</sub> ) <sub>5</sub>  | COOH                     | t-butyl        |
|    | 70  | 1 | (CH <sub>2</sub> ) <sub>6</sub>  | COOH                     | Pentyl         |
|    | 71  | 1 | (CH <sub>2</sub> ) <sub>7</sub>  | COOH                     | Hexyl          |
| 30 | 72  | 1 | (CH <sub>2</sub> ) <sub>8</sub>  | COOH                     | Septyl         |

| No.   | n | D                                | R2  | R1         |
|-------|---|----------------------------------|---|------------|
| 73    | 1 | (CH <sub>2</sub> ) <sub>9</sub>  | COOH  | Octyl      |
| 74    | 1 | (CH <sub>2</sub> ) <sub>10</sub> | COOH  | Nonyl      |
| 75    | 1 | C <sub>2</sub> H <sub>2</sub>    | COOH  | Cyclohexyl |
| 76    | 1 | bond                             |    | benzyl     |
| 5 77  | 1 | bond                             |    | benzyl     |
| 78    | 1 | bond                             |    | benzyl     |
| 79    | 1 | bond                             |   | benzyl     |
| 80    | 1 | bond                             |  | benzyl     |
| 81    | 1 | bond                             |  | benzyl     |
| 10 82 | 1 | bond                             |  | benzyl     |
| 83    | 1 | bond                             |  | benzyl     |

| No. | n  | D    | R2  | R1  |        |
|-----|----|------|---|---|--------|
| 84  | 1  | bond |    | benzyl  |        |
| 85  | 1  | bond |    | benzyl  |        |
| 86  | 1  | bond |    | benzyl  |        |
| 87  | 1  | bond |   | benzyl  |        |
| 5   | 88 | 1    | bond  |  | benzyl |
| 89  | 1  | bond |  | benzyl  |        |
| 90  | 1  | bond |  | benzyl  |        |
| 91  | 1  | bond |  | benzyl  |        |

| No.  | n | D    | R <sub>2</sub>   | R <sub>1</sub> |
|------|---|------|--|----------------|
| 92   | 1 | bond |   | benzyl         |
| 93   | 1 | bond |   | benzyl         |
| 94   | 1 | bond |  | benzyl         |
| 95   | 1 | bond | CH <sub>2</sub> OH   | benzyl         |
| 5 96 | 1 | bond | CONH <sub>2</sub>  | benzyl         |
| 97   | 1 | bond | CN   | benzyl         |



| 10 | No. | n | D               | R <sub>2</sub>    | L              | R <sub>1</sub>     |
|----|-----|---|-----------------|-------------------|----------------|--------------------|
|    | 101 | 1 | CH <sub>2</sub> | OH                | 1,2-dioxoethyl | benzyl             |
|    | 102 | 1 | bond            | -CN               | 1,2-dioxoethyl | 1,1-dimethylpropyl |
|    | 103 | 1 | bond            | tetrazole         | 1,2-dioxoethyl | 1,1-dimethylpropyl |
|    | 104 | 2 | bond            | CONH <sub>2</sub> | 1,2-dioxoethyl | 1,1-dimethylpropyl |

| No. | n | D    | R <sub>2</sub> | L              | R <sub>1</sub>     |
|-----|---|------|----------------|----------------|--------------------|
| 105 | 1 | bond | COOH           | 1,2-dioxoethyl | 1,1-dimethylpropyl |
| 106 | 2 | bond | COOH           | 1,2-dioxoethyl | 1,1-dimethylpropyl |

5

#### Affinity for FKBP12

The compounds used in the inventive methods and pharmaceutical compositions have an affinity for the FK506 binding protein, particularly FKBP12. The inhibition of the prolyl peptidyl *cis-trans* isomerase activity of FKBP may be measured as an indicator of this affinity.

#### K<sub>i</sub> Test Procedure

Inhibition of the peptidyl-prolyl isomerase (rotamase) activity of the compounds used in the inventive methods and pharmaceutical compositions can be evaluated by known methods described in the literature (Harding et al., *Nature*, 1989, 341:758-760; Holt et al. *J. Am. Chem. Soc.*, 115:9923-9938). These values are obtained as apparent K<sub>i</sub>'s.

The *cis-trans* isomerization of an alanine-proline bond in a model substrate, N-succinyl-Ala-Ala-Pro-Phe-*p*-nitroanilide, is monitored spectrophotometrically in a chymotrypsin-coupled assay, which releases *para*-nitroanilide from the *trans* form of the substrate. The inhibition of this reaction caused by the addition of different concentrations of inhibitor is determined, and the data is analyzed as a change in first-order rate constant as a function of inhibitor concentration to yield the apparent K<sub>i</sub> values.

In a plastic cuvette are added 950  $\mu$ l of ice cold assay buffer (25 mM HEPES, pH 7.8, 100 mM NaCl), 10  $\mu$ l of FKBP (2.5 mM in 10 mM Tris-Cl pH 7.5, 100 mM NaCl, 1 mM dithiothreitol), 25  $\mu$ l of chymotrypsin (50 mg/ml in 1 mM HCl) and 10  $\mu$ l of test compound at various concentrations in



dimethyl sulfoxide. The reaction is initiated by the addition of 5 ml of substrate (succinyl-Ala-Phe-Pro-Phe-para-nitroanilide, 5 mg/ml in 2.35 mM LiCl in trifluoroethanol).

The absorbance at 390 nm versus time is monitored for 90  
5 seconds using a spectrophotometer and the rate constants are determined from the absorbance versus time data files.

#### Route of Administration

To effectively treat vision loss or promote vision  
10 regeneration, the compounds used in the inventive methods and pharmaceutical compositions must readily affect the targeted areas. For these purposes, the compounds are preferably administered [topically to the skin.]

[For topical application to the skin, the compounds can  
15 be formulated into suitable ointments containing the compounds suspended or dissolved in, for example, mixtures with one or more of the following: mineral oil, liquid petrolatum, white petrolatum, propylene glycol, polyoxyethylene polyoxypropylene compound, emulsifying wax  
20 and water. Alternatively, the compounds can be formulated into suitable lotions or creams containing the active compound suspended or dissolved in, for example, a mixture of one or more of the following: mineral oil, sorbitan monostearate, polysorbate 60, cetyl esters wax, cetearyl  
25 alcohol, 2-octyldodecanol, benzyl alcohol and water.]

Other routes of administration known in the pharmaceutical art are also contemplated by this invention.

#### Dosage

30 Dosage levels on the order of about 0.1 mg to about 10,000 mg of the active ingredient compound are useful in the treatment of the above conditions, with preferred levels of about 0.1 mg to about 1,000 mg. The specific dose level for any particular patient will vary depending upon a variety of  
35 factors, including the activity of the specific compound

employed; the age, body weight, general health, sex and diet of the patient; the time of administration; the rate of excretion; drug combination; the severity of the particular disease being treated; and the form of administration.

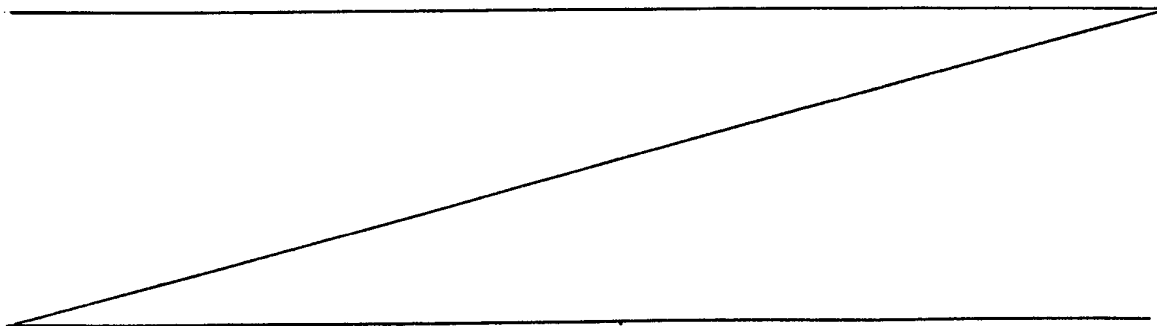
5 Typically, *in vitro* dosage-effect results provide useful guidance on the proper doses for patient administration. Studies in animal models are also helpful. The considerations for determining the proper dose levels are well known in the art.

10 The compounds can be administered with other agents for treating vision loss, preventing vision degeneration, or promoting vision regeneration. Specific dose levels for such other agents will depend upon the factors previously stated and the effectiveness of the drug combination.

15 The following examples are illustrative of preferred embodiments of the invention and are not to be construed as limiting the invention thereto. All polymer molecular weights are mean average molecular weights. All percentages are based on the percent by weight of the final delivery  
20 system or formulation prepared unless otherwise indicated and all totals equal 100% by weight.

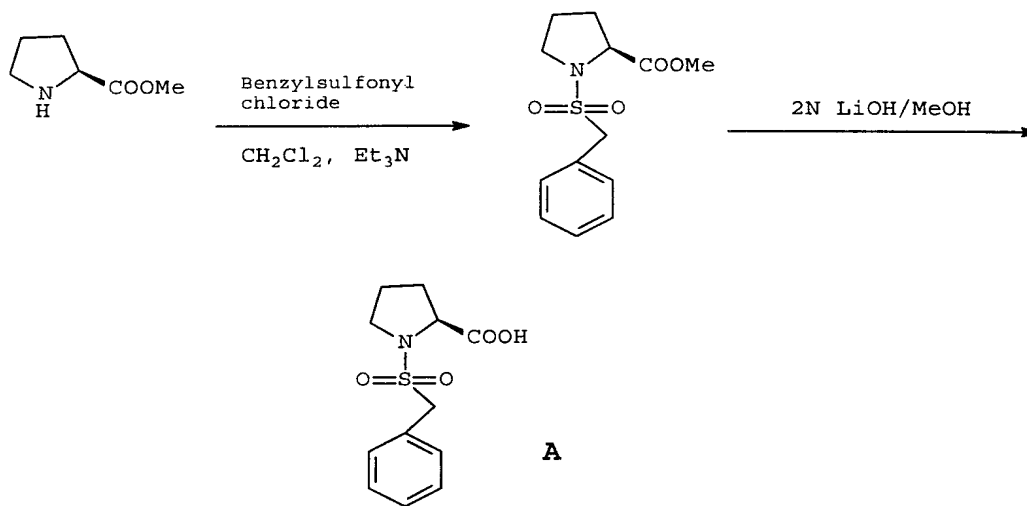
#### EXAMPLES

The inventive compounds may be prepared by a variety of  
25 synthetic sequences that utilize established chemical transformations. An exemplary general pathway to the present compounds is described in Scheme I, Scheme II, and Scheme III.



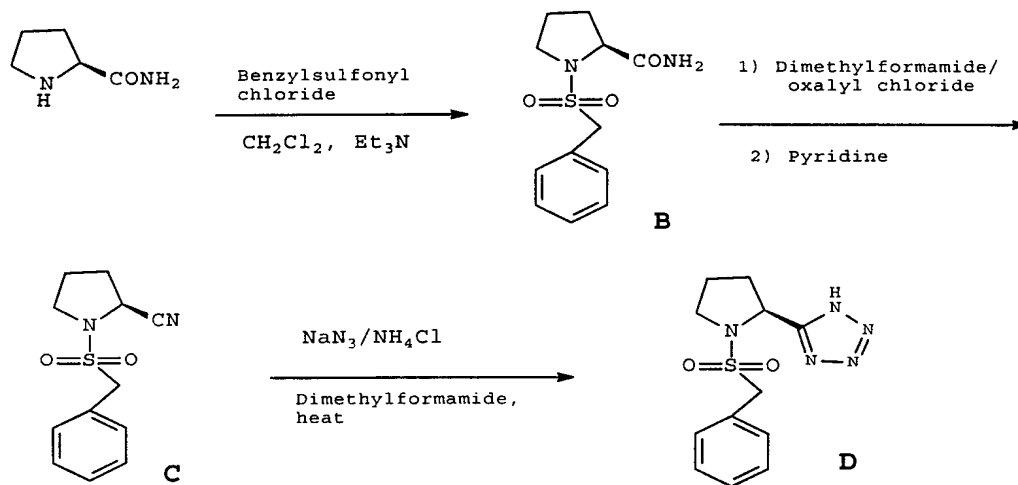
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**SCHEME I**



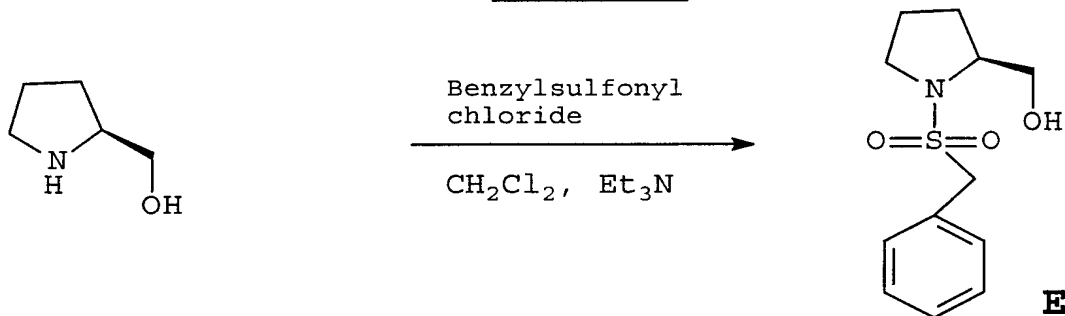
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**SCHEME II**



10

**SCHEME III**



**EXAMPLE 1**Synthesis of (2S)-N-(benzylsulfonyl)-2-pyrrolidinecarboxylic acid (Compound 1) (A)

To a cooled (0°C) solution of proline methyl ester hydrochloride salt (5.0 g; 30.19 mmol) in 200 mL of methylene chloride was added triethylamine (35mL) and benzenesulfonyl chloride (5.75 g; 30.19 mmol). The mixture was stirred for one hour at 0°C and then washed with 2 x 100 mL of water. The organic phase was dried and concentrated. Chromatography eluting with 50% EtOAc/hexane delivered 8.14 g (5%) of the N-sulfonamide methyl ester, which was dissolved in 120 mL of methanol, cooled to 0°C, and treated with 40 mL of 1 N lithium hydroxide. The mixture was stirred for 1 hour at 0°C and then overnight at room temperature. After making the reaction mixture acidic (pH 1) with 1 N HCl, the product was extracted into methylene chloride and dried and concentrated to yield 4.25 g of (2S)-N-(benzylsulfonyl)-2-pyrrolidinecarboxylic acid (A) as a white solid, <sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz): d 1.85-1.90 (m, 2H); 2.08 (m, 1H); 2.18 (m, 1H); 3.04 (m, 1H); 3.27 (m, 1H); 4.32-4.35 (m, 2H); 4.45 (m, 1H); 4.45 (m, 2H); 7.36 (m, 3H); 7.48 (m, 2H); 10.98 (br, 1H).

**EXAMPLE 2**Synthesis of (2S)-1-(phenylmethanesulfonyl)-2-hydroxymethyl pyrrolidine (Compound 95) (E).

To a solution of (S)-(+)-2-pyrrolidinemethanol (1.01 g, 10 mmol) and triethylamine (1.5 ml, 11 mmol) in 30 ml methylene chloride was added 1.9 g (10 mmol) α-toluenesulfonyl chloride at 0°C with stirring. The reaction was gradually warmed up to room temperature and stirred overnight. The mixture was diluted with water, and extracted into 200 ml methylene chloride. The organic extract was concentrated and further purified by silica gel to give 1.5 g product as a white solid (58.9% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>):

d 01.71-1.88 (m, 4H); 2.05 (br, 1H, OH); 3.22 (m, 2H); 3.47 (m, 2H); 3.67 (m, 1H); 4.35 (s, 2H); 7.26-7.44 (m, 5H, aromatic).

5

**EXAMPLE 3**

Synthesis of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarboxamide (Compound 96) (B).

To a solution of L-prolinamide (2.28 g, 20 mmol) and triethylamine (5.76 ml, 42 mmol) in 40 ml methylene chloride was added 3.92 g (20 mmol)  $\alpha$ -toluenesulfonyl chloride at 0°C with stirring. The reaction was gradually warmed up to room temperature and stirred overnight. The mixture was diluted with water, and extracted into 200 ml methylene chloride. The organic extract was concentrated and further purified by silica gel to give 3.0 g product as a white solid (55.7% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>): d 01.89 (m, 3H); 2.25 (m, 1H); 3.40 (m, 1H); 3.50 (m, 1H); 3.96 (m, 1H); 4.35 (s, 2H); 7.39-7.45 (m, 5H, aromatic).

20

**EXAMPLE 4**

Synthesis of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarbonitrile (Compound 97) (C).

To a solution of 0.67 ml DMF (8.7 mmol) in 10 ml acetonitrile at 0°C was added 0.70 ml (8.0 mmol) oxalyl chloride. A white precipitate was formed immediately and was accompanied by gas evolution. When complete, a solution of 2.0 g (7.5 mmol) of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarboxamide in 5.0 ml acetonitrile was added. When the mixture became homogeneous, 1.35 ml (16.5 mmol) pyridine was added. After 5 min., the mixture was diluted with water, and extracted by 200 ml ethyl acetate. The organic layer was concentrated and further purified by silica gel to give 1.5 g product as a white solid (80% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>): d 01.92 (m, 2H); 2.01 (m, 1H); 2.11 (m, 1H); 3.45 (m, 2H); 4.35 (s, 2H); 4.65 (m, 1H); 7.26-7.45

(m, 5H, aromatic).

#### EXAMPLE 5

Synthesis of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinetetrazole (Compound 4) (D).

A mixture of (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinecarbonitrile (250 mg, 1 mmol), NaN<sub>3</sub> (81 mg, 1.3 mmol) and NH<sub>4</sub>Cl (70 mg, 1.3 mmol) in 3 ml DMF was stirred at 130°C for 16 hours. The mixture was concentrated and purified by silica gel to give 120 mg product as a white solid (41.1% yield). <sup>1</sup>H NMR (CDCl<sub>3</sub>): d 01.95 (m, 2H); 2.21 (m, 1H); 2.90 (m, 1H); 3.40 (m, 2H); 4.27 (s, 2H); 5.04 (m, 1H); 7.36-7.41 (m, 5H, aromatic); 8.05 (s, 1H, NH).

#### Example 6

Synthesis of 3-phenyl-1-propyl (2S)-1-(3,3-dimethyl-1,2-dioxopentyl)-2-pyrrolidinecarboxylate (1)

Methyl (2S)-1-(1,2-dioxo-2-methoxyethyl)-2-pyrrolidinecarboxylate

A solution of L-proline methyl ester hydrochloride (3.08 g; 18.60 mmol) in dry methylene chloride was cooled to 0°C and treated with triethylamine (3.92 g; 38.74 mmol; 2.1 eq). After stirring the formed slurry under a nitrogen atmosphere for 15 min, a solution of methyl oxalyl chloride (3.20 g; 26.12 mmol) in methylene chloride (45 ml) was added dropwise. The resulting mixture was stirred at 0°C for 1.5 hour. After filtering to remove solids, the organic phase was washed with water, dried over MgSO<sub>4</sub> and concentrated. The crude residue was purified on a silica gel column, eluting with 50% ethyl acetate in hexane, to obtain 3.52 g (88%) of the product as a reddish oil. Mixture of cis-trans amide rotamers; data for trans rotamer given. <sup>1</sup>H NMR (CDCl<sub>3</sub>): d 1.93 (dm, 2H); 2.17 (m, 2H); 3.62 (m, 2H); 3.71 (s, 3H); 3.79, 3.84 (s, 3H total); 4.86 (dd, 1H, J = 8.4, 3.3).

Methyl (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidinecarboxylate

A solution of methyl (2S)-1-(1,2-dioxo-2-methoxyethyl)-2-pyrrolidinecarboxylate (2.35 g; 10.90 mmol) in 30 ml of tetrahydrofuran (THF) was cooled to -78°C and treated with 14.2 ml of a 1.0 M solution of 1,1-dimethylpropylmagnesium chloride in THF. After stirring the resulting homogeneous mixture at -78°C for three hours, the mixture was poured into saturated ammonium chloride (100 ml) and extracted into ethyl acetate. The organic phase was washed with water, dried, and concentrated, and the crude material obtained upon removal of the solvent was purified on a silica gel column, eluting with 25% ethyl acetate in hexane, to obtain 2.10 g (75%) of the oxamate as a colorless oil. <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 0.88 (t, 3H); 1.22, 1.26 (s, 3H each); 1.75 (dm, 2H); 1.87-2.10 (m, 3H); 2.23 (m, 1H); 3.54 (m, 2H); 3.76 (s, 3H); 4.52 (dm, 1H, J = 8.4, 3.4).

Synthesis of (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidinecarboxylic acid

A mixture of methyl (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidinecarboxylate (2.10 g; 8.23 mmol), 1 N LiOH (15 ml), and methanol (50 ml) was stirred at 0°C for 30 minutes and at room temperature overnight. The mixture was acidified to pH 1 with 1 N HCl, diluted with water, and extracted into 100 ml of methylene chloride. The organic extract was washed with brine and concentrated to deliver 1.73 g (87%) of snow-white solid which did not require further purification. <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 0.87 (t, 3H); 1.22, 1.25 (s, 3H each); 1.77 (dm, 2H); 2.02 (m, 2H); 2.17 (m, 1H); 2.25 (m, 1H); 3.53 (dd, 2H, J = 10.4, 7.3); 4.55 (dd, 1H, J = 8.6, 4.1).

3-Phenyl-1-propyl (2S)-1-(3,3-dimethyl-1,2-dioxopentyl)-2-pyrrolidinecarboxylate (1)

A mixture of (2S)-1-(1,2-dioxo-3,3-dimethylpentyl)-2-pyrrolidine-carboxylic acid (600 mg; 2.49 mmol), 3-phenyl-1-

propanol (508 mg; 3.73 mmol), dicyclohexylcarbodiimide (822 mg; 3.98 mmol), camphorsulfonic acid (190 mg; 0.8 mmol) and 4-dimethylaminopyridine (100 mg; 0.8 mmol) in methylene chloride (20 ml) was stirred overnight under a nitrogen atmosphere. The reaction mixture was filtered through Celite to remove solids and concentrated in vacuo, and the crude material was purified on a flash column (25% ethyl acetate in hexane) to obtain 720 mg (80%) of Example 1 as a colorless oil. <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 0.84 (t, 3H); 1.19 (s, 3H); 1.23 (s, 3H); 1.70 (dm, 2H); 1.98 (m, 5H); 2.22 (m, 1H); 2.64 (m, 2H); 3.47 (m, 2H); 4.14 (m, 2H); 4.51 (d, 1H); 7.16 (m, 3H); 7.26 (m, 2H).

**Figure 1. GPI 1046 protects retinal ganglion cells against degeneration following retinal ischemia.**

Retinal ganglion cells were retrogradely labeled in adult rats by bilateral injection of fluorogold in their lateral geniculate nuclei. Labeled ganglion cells in the normal rat retina appear as white profiles against the dark background (Figure 1A). Complete retinal ischemia was produced by infusing normal saline solution into the retinal vitreous cavity of each eye until the intraocular pressure exceeded arterial blood pressure. 28 days after the ischemic episode extensive degeneration of retinal ganglion cell was evidenced by massive reduction in the density of fluorogold labeled cells (Figure 1B). Administration of GPI 1046 (10mg/kg, s.c.) 1 hour prior to the ischemic episode and at 10mg/kg/day for the next four days produced noticeable protection of a large proportion of the vulnerable ganglion cell population (Figure 1C).

**Figure 2. GPI 1046 prevents degeneration of optic nerve axons and myelin following retinal ischemia**

Examination of the optic nerves from the same retinal ischemia cases reveals that GPI 1046 produces dramatic



protection of optic nerve element from ischemic degeneration. Toluidine blue staining of epon embedded optic nerve cross sections revealed the detail of myelin sheaths (white circles) and optic nerve axons (black centers) in the normal  
5 rat optic nerve. Optic nerves from vehicle treated cases examined 28 days after a 1 hour retinal ischemic episode are characterized by a decreased density of optic nerve axons and the appearance of numerous degenerating myelin figures (bright white filled circles). Treatment with GPI 1046  
10 protected the majority of optic nerve axons from degeneration and also dramatically decreased the density of degenerating myelin figures.

**Figure 3. GPI 1046 provides moderate protection against  
15 retinal ganglion cell death after optic nerve transection**

Complete transection of the optic nerve 5 mm from the eyeball produces massive degeneration of retinal ganglion cells, representing loss of >87% of the normal ganglion cell population 90 days after the injury (Table 1). Few spared  
20 fluorogold pre labeled ganglion cells are present in vehicle treated cases (large white figures) among a population of small microglia that digest the debris of the degenerating cells and take up the fluorogold label (Figure 3A). Treatment with GPI 1046 for 14 days resulted in a small but  
25 not significant increase in the density of retinal ganglion cells that survived 90 days after transection (Table 1) but treatment with GPI 1046 for the first 28 days after transection produced moderate but significant protection of 12.6% of the vulnerable ganglion cell population (Table 1,  
30 Figure 3B).

**Figure 4. GPI 1046 treatment duration significantly affects the process of optic nerve axonal degeneration after transection.**

Examination of optic nerve axon density in the proximal stump of the optic nerve from the same cases revealed a more dramatic protection afforded by GPI 1046 treatment. 90 days after transection few ganglion cell axons remain within the optic nerve (Figure 4B), representing only 5.6% of the normal population. The loss of axons reflects both the death of retinal ganglion cells and the regression or "dying back" of the axons of ~ 70% of the small surviving ganglion cell population into the retina itself (Table 1). Treatment with GPI 1046 for the first 14 days after optic nerve transection produced a small but significant 5.3% protection of optic nerve axons (Figure 4D, Table 1), but treatment with the same dose of GPI 1046 for 28 days resulted in the protection of optic nerve axons for the vast majority (81.4%) of spared retinal ganglion cells (Figure 4C, Table 1).

**Figure 5. GPI 1046 treatment produces a greater effect on optic nerve axons than ganglion cell bodies**

This summary figure shows data from Figure 3 ganglion cell protection and higher power photomicrographs of optic nerve axon protection (Figure 5A&B, upper panels). 28 day treatment with GPI 1046 produced a significant increase in the density of large, and particularly medium and small caliber optic nerve axons (Figure 5C&D, lower panels).

**Figure 6. GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the proximal stump**

Myelin basic protein immunohistochemistry labels fascicles (darker labeled 'islands') of myelinated axons in the normal optic nerve (Figure 6A, upper left). 90 days after transection extensive degeneration of myelin is evident in vehicle treated cases, characterized by the loss of fascicular organization and the appearance of numerous large dense degenerating myelin figures (Figure 6B, upper right).

Treatment with GPI 1046 for the first 14 days after optic nerve transection did not alter the pattern of myelin degeneration (Figure 6C, lower left panel), and yielded an insignificant 1.6% quantitative recovery in myelin density (Table 1). Extending the GPI 1046 treatment course through the first 28 days after optic nerve transection produced a dramatic preservation of the fascicular staining pattern for myelin basic protein in the proximal stump of the optic nerve and decreased the density of degenerating myelin figures (Figure 6D, lower right panel), representing a '70% recovery of myelin density (Table 1).

**Figure 7. FKBP-12 immunohistochemistry labels oligodendroglia (large dark cells with fibrous processes), the cells which produce myelin, located between the fascicles of optic nerve fibers, and also some optic nerve axons.**

**Figure 8. GPI 1046 treatment for 28 days after optic nerve transection prevents myelin degeneration in the distal stump.**

Complete transection of the optic nerve leads to degeneration of the distal segments (axon fragments disconnected from the ganglion cell bodies), and the degeneration of their myelin sheaths. 90 days after transection (Figure 8B) myelin basic protein immunohistochemistry reveals the near total loss of fascicular organization (present in the normal optic nerve, Figure 8A) and the presence of numerous dense degenerating myelin figures. Quantitation reveals that the cross sectional area of the transected distal stump shrinks by 31% and loses approximately 1/2 of its myelin (Table 1).

Treatment with GPI 1046 for the first 14 days after transection did not protect against shrinkage of the distal stump but did slightly increase the density of myelin, though the density of degenerating myelin figures remained high (Figure 8C, Table 1). GPI 1046 treatment through the first

28 days produced dramatic protection of the fascicular pattern of myelin labeling, decreased the density of degenerating myelin figures, prevented cross sectional shrinkage of the distal stump of the transected nerve and  
5 maintained the myelin levels at ~99% of normal levels (Figure 8D, Table 1).

**Figure 9. 28 day treatment with GPI 1046 treatment beginning 8 weeks after onset of streptozotocin induced diabetes decreases the extent of neovascularization in the inner and  
10 outer retina and protects neurons in the inner nuclear layer (INL) and ganglion cell layer (GCL) from degeneration.**

Negative images of cresyl violet stained tangential retinal sections reveals perikarya in the three cellular layers  
15 (Figure 9A). The retinae of streptozotocin treated animals administered only vehicle (Figure 9B) exhibited loss of cells from the ONL and INL, decreased thickness of the Outer plexiform layer (the dark area between ONL and INL) and a dramatic increase in the size and density of retinal blood  
20 vessels (large black circular outlines) in the INL, OPL, ONL and the photoreceptor layer (PR, the gray fuzzy area above the ONL). GPI 1046 treatment reduced neovascularization (i.e. prevented the proliferation of blood vessels) in the PR, ONL, OPL and INL. Although GPI 1046 did not appear to  
25 protect against neuronal loss in the ONL, it appeared to decrease the loss of neurons in both the INL and GCL compared to streptozotocin/vehicle treated controls.

#### Example 7

30 **In Vivo Retinal Ganglion Cell**  
**and Optic Nerve Axon Tests**

The extent of degeneration reduction or prevention in retinal ganglion cells and optic nerve axons was determined in a vision loss model utilizing surgical optic nerve

transection to simulate mechanical damage to the optic nerve. The effects of several neuroimmunophilin FKBP ligands on retinal ganglion cells neuroprotection and optic nerve axon density was determined experimentally, comparing 14 day and 5 28 day neuroimmunophilin FKBP ligand treatments. The effects of treatment with neuroimmunophilin FKBP ligands on retinal ganglion cells and optic nerve axons was correlated.

#### Surgical Procedures

Adult male Sprague Dawley rats (3 months old, 225-250 10 grams) were anesthetized with a ketamine (87mg/kg) and xylazine (13mg/kg) mixture. Retinal ganglion cells were pre-labeled by bilateral stereotaxic injection of the fluorescent retrogradely transported marker fluoro-gold (FG, 0.5 microliters of 2.5% solution in saline) at the coordinates of 15 the LGNd (4.5 millimeters post  $\beta$ , 3.5 millimeters lateral, 4.6 millimeters below dura). Four days later, FG labeled rats underwent a second surgery for microsurgical bilateral intraorbital optic nerve transection 4-5 millimeters behind the orbit.

20 Experimental animals were divided into six experimental groups of six rats (12 eyes) per group. One group received a neuroimmunophilin FKBP ligand (10 milligrams per kg per day sc in PEG vehicle (20 percent propylene glycol, 20 percent ethanol, and 60 percent saline)) for 14 days. A second group 25 received the same neuroimmunophilin FKBP ligand dose for 28 days. Each treated group had a corresponding sham/surgery and transection control group which received corresponding 14 or 28 day dosing with the vehicle only.

All animals were sacrificed 90 days after optic nerve 30 transection and perfused pericardially with formalin. All eyes and optic nerves stumps were removed. Cases were excluded from the study if the optic nerve vasculature was damaged or if FG labeling was absent in the retina.

#### Retinal Ganglion Cell Counts

35 Retinas were removed from eyes and prepared for

wholemount analysis. For each group, five eyes with dense and intense FG labeling were selected for quantitative analysis using a 20 power objective. Digital images were obtained from five fields in the central retina (3-4 millimeters radial to optic nerve head). FG labeled Large (>18  $\mu\text{m}$ ), medium (12-16  $\mu\text{m}$ ), and small (<10  $\mu\text{m}$ ) ganglion cells and microglia were counted in five 400  $\mu\text{m}$  by 400  $\mu\text{m}$  fields per case, 5 cases per group.

#### Examination of Optic Nerves

10 Proximal and distal optic nerve stumps were identified, measured, and transferred to 30% sucrose saline. The proximal stumps of five nerves were blocked and affixed to a chuck, and 10 micron cross sections were cut on a cryostat; one in ten sections were saved per set. Sections including  
15 the region 1-2 mm behind the orbit were reacted for RT97 neurofilament immunohistochemistry. Analysis of optic nerve axon density was performed using a 63 power oil immersion lens, a Dage 81 camera, and the Simple Image Analysis program. RT97 positive optic nerve axons were counted in  
20 three 200  $\mu\text{m}$  by 200  $\mu\text{m}$  fields per nerve. The area of the nerve was also determined for each case at 10 power.

As depicted graphically in Table I&II, the 14 day course of treatment with a neuroimmunophilin FKBP ligand provided moderate neuroprotection of retinal ganglion cells observed  
25 28 days after optic nerve transection. However, by 90 days after transection, only 5% of the ganglion cell population remained viable.

90 days after optic nerve transection the number of axons persisting in the proximal stump of the optic nerve  
30 represented approximately one half of the number of surviving ganglion cells in groups of animals that received vehicle alone or the 14 day course of treatment with a neuroimmunophilin FKBP ligand. These results indicate that over half of the transected ganglion cell axons retract  
35 beyond the optic nerve head, and that treatment with a

neuroimmunophilin FKBP ligand during the first 14 days after optic nerve transection is not sufficient to arrest this retraction.

As depicted graphically in Table I&II, more prolonged  
5 treatment with a neuroimmunophilin FKBP ligand during the 28  
day course of treatment produced a moderate increase in  
retinal ganglion cell neuroprotection. Approximately 12% of  
the vulnerable retinal ganglion cell population was  
protected. A similar proportion (~50%) of optic nerve axon  
10 density sparing was also observed. These results demonstrate  
the startling result that extending the duration of treatment  
with a neuroimmunophilin FKBP ligands to 28 days after  
transection completely arrests the regression of damaged  
axons for essentially the entire surviving population of  
15 retinal ganglion cells.

Additional results are set forth in Tables III & IV.

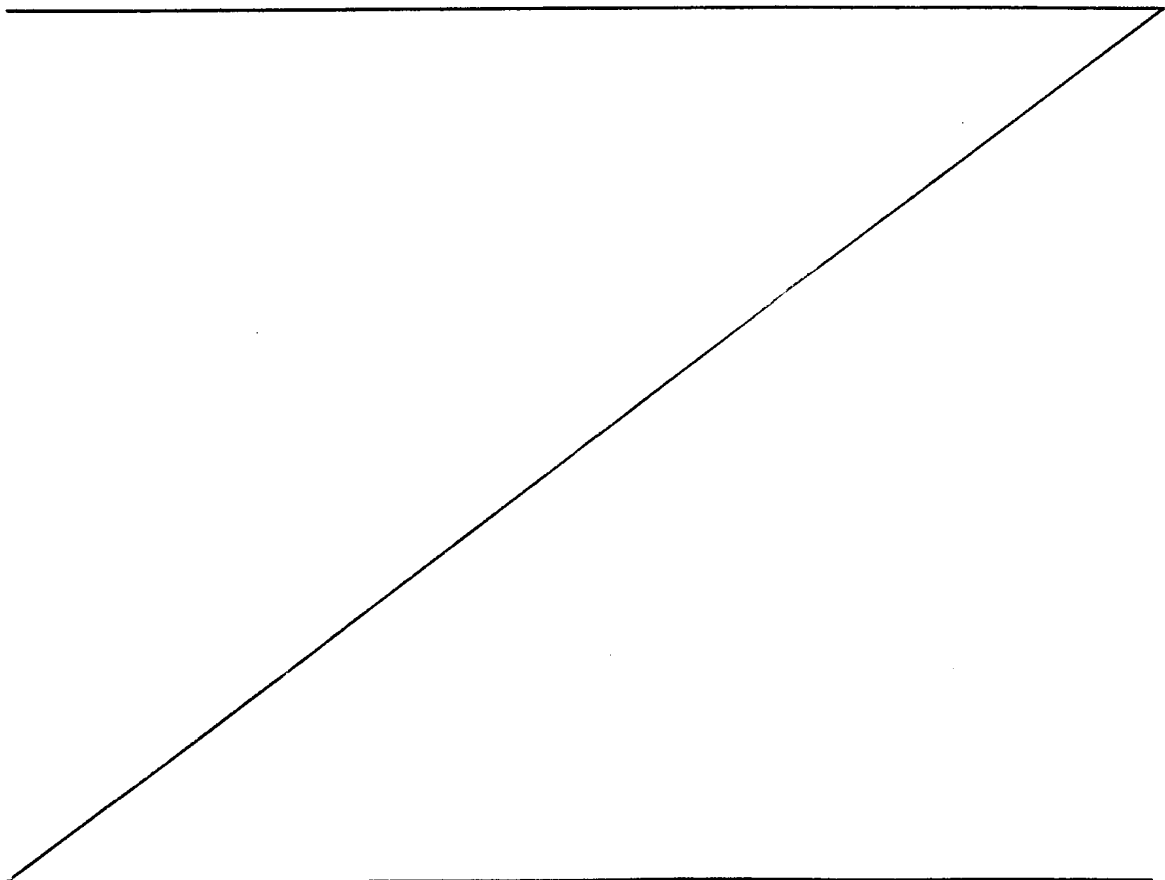


Table 1

Effect of prolonged GPI 1046 treatment on retinal ganglion cell survival,  
optic nerve axon preservation, and myelination 90 days after optic nerve transection

| GROUP                    | RGC<br>Counts <sup>1</sup> | ON Axon<br>density <sup>2</sup> | ON head<br>area<br>(%sham) | % RGCs<br>Rescued | increased<br>ON axon<br>density <sup>3</sup> | Spared<br>RGC<br>population | ON axon<br>Count <sup>4</sup> | %<br>surviving<br>RGCs with<br>ON axons | Proximal optic nerve<br>myelin basic protein<br>Density <sup>5</sup> |
|--------------------------|----------------------------|---------------------------------|----------------------------|-------------------|--|-----------------------------|-------------------------------|---|--|
| Sham                     | 290 ± 14.8                 | 7600*                           | 100%                       | -                 |  | 120,000*                    | 120,000                       | 100%                                    | normal   |
| ONT/Vehicle              | 35.9 ± 2.8                 | 428 ± 34                        | 68%                        | (87% loss)        |  | 14,855                      | 4593                          | 30.9%                                   | 52 ± 5.2 SEM<br>% loss   |
| ONT/ 14 days<br>GPI 1046 | 49 ± 5.3                   | 569 ± 23                        | 76%                        | 5.3%              | 1.5X   | 20,275                      | 6820                          | 33.6%                                   | 1.6 ± 3.0 SEM<br>% recovery  |
| ONT/ 28 days<br>GPI 1046 | 67.9 ± 5.8*                | 1526 ± 120*                     | 95%*                       | 12.6%*            | 5.0X   | 28,096*                     | 22,861*                       | 81.4%                                   | 70 ± 6.3 SEM<br>% recovery*  |

\*significance p<.001

<sup>1</sup> Mean density + SEM of Fluoro-gold labeled retinal ganglion cells (RGC) in 400 µm x 400 µm sample gridfields.

<sup>2</sup> mean density + SEM of RT97 neurofilament antibody labeled optic nerve (ON) axons in  
200 µm x 200µm region of interest

\*estimate for 200 µm x 200µm region in normal optic nerve assuming 120,000 RGC axons in normal rat optic nerve,  
measured to be 0.630 mm<sup>2</sup> mean cross sectional area

<sup>3</sup> adjusted for optic nerve diameter

<sup>4</sup> calculated by multiplying axonal density by ON area

<sup>5</sup> determined from 20X analysis of % areal coverage of optic nerve cross section



Table II

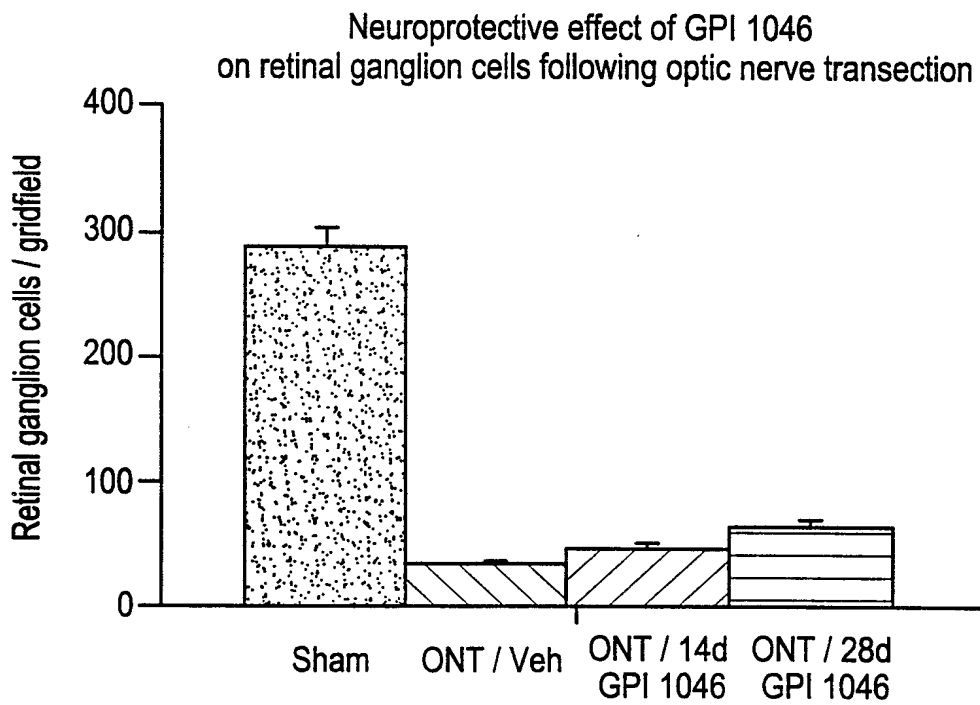


Table III  
Correlation between Retinal Ganglion Cell and Optic Nerve Axon Sparing at 90 days following optic nerve transection and 14 or 28 day GPI 1046 treatment

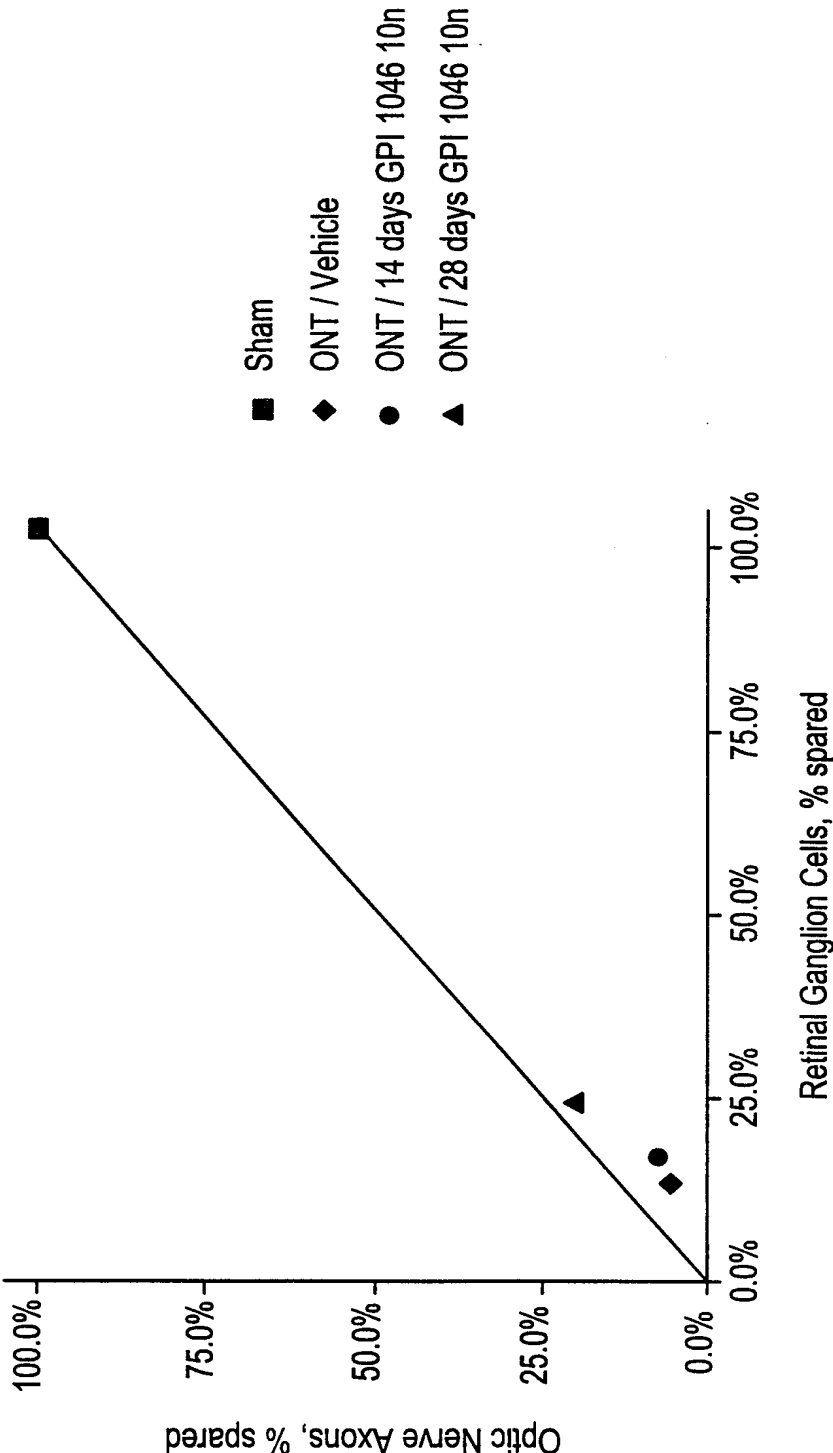
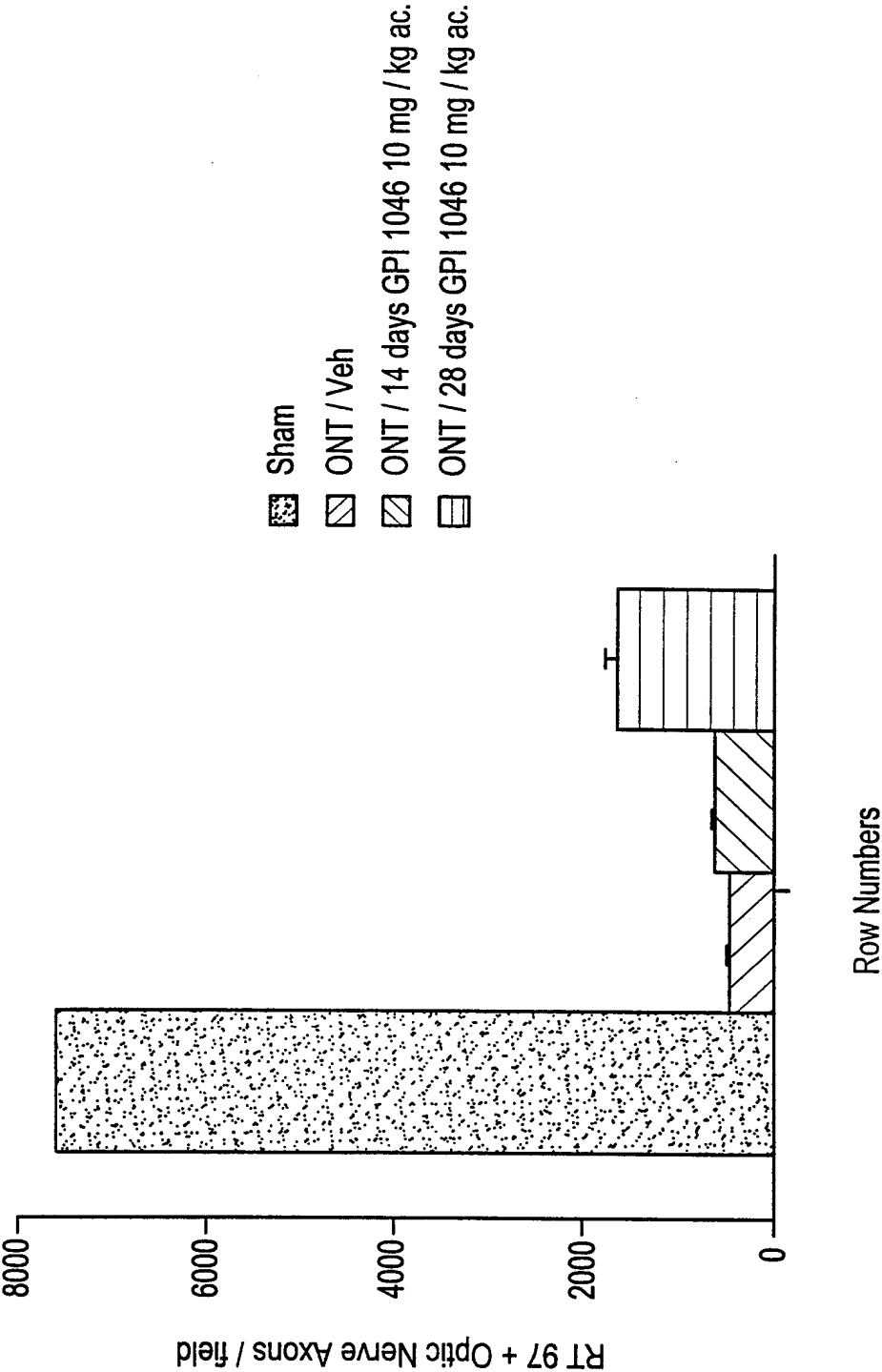


Table IV

GPI 1046 preserves optic nerve axons  
in the proximal stump following transection



Example 8

A patient is suffering from macular degeneration. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

10

Example 9

A patient is suffering from glaucoma, resulting in cupping of the optic nerve disc and damage to nerve fibers. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

20

Example 10

A patient is suffering from cataracts requiring surgery. Following surgery, a derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

30

Example 11

A patient is suffering from an impairment or blockage of retinal blood supply relating to diabetic retinopathy, ischemic optic neuropathy, or retinal artery or vein blockage. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be

35

administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

5 Example 12

A patient is suffering from a detached retina. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

### Example 13

15           A patient is suffering from tissue damage caused by inflammation associated with uveitis or conjunctivitis. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the  
20 patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

**Example 14**

25       A patient is suffering from photoreceptor damage caused  
by chronic or acute exposure to ultraviolet light. A  
derivative as identified above, alone or in combination with  
one or more other neoplastic factors, or a pharmaceutical  
composition comprising the same, may be administered to the  
30 patient. A reduction in vision loss, prevention of vision  
degeneration, and/or promotion of vision regeneration are/is  
expected to occur following treatment.

### Example 15

35        A patient is suffering from optic neuritis.        A

derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision  
5 degeneration, and/or promotion of vision regeneration are/is expected to occur following treatment.

**Example 16**

A patient is suffering from tissue damage associated  
10 with a "dry eye" disorder. A derivative as identified above, alone or in combination with one or more other neoplastic factors, or a pharmaceutical composition comprising the same, may be administered to the patient. A reduction in vision loss, prevention of vision degeneration, and/or promotion of  
15 vision regeneration are/is expected to occur following treatment.

**Example 17**

Efficacy of representative compounds from different  
20 immunophilin ligand series in protecting retinal ganglion cell axons from degeneration following optic nerve transection is set forth in Table V.

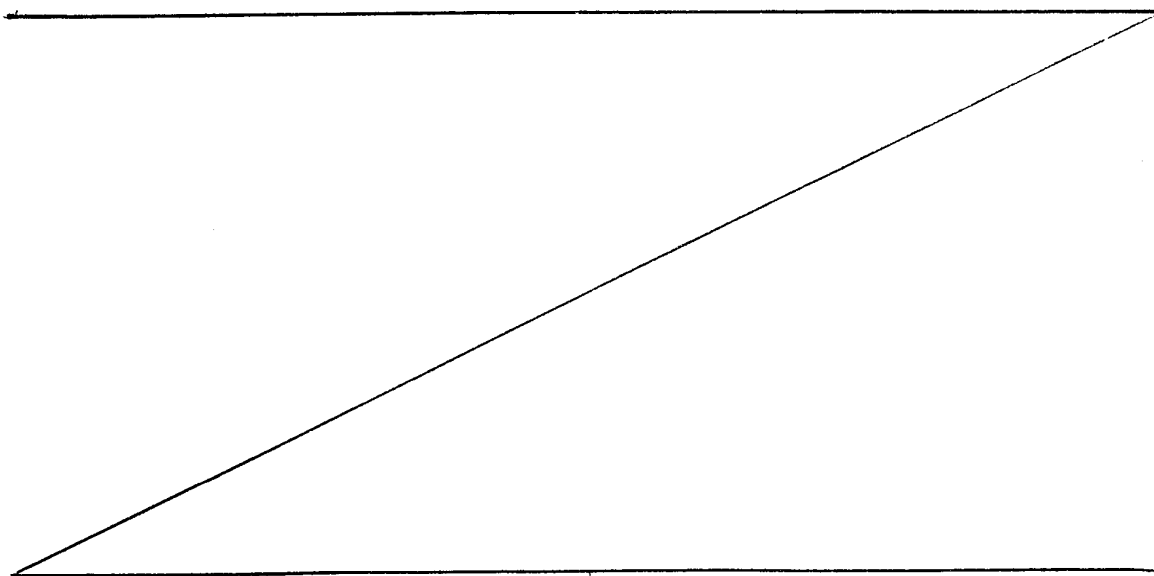


Table V

Efficacy of representative compounds from different immunophilin ligand series in protecting retinal ganglion cell axons from degeneration following optic nerve transection

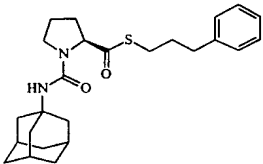
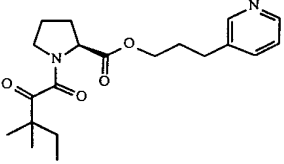
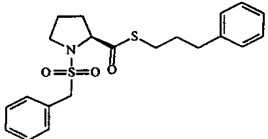
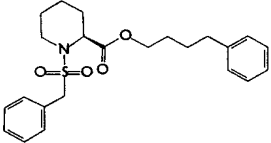
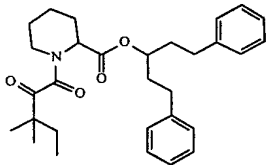
|    |               |   |   |   |
|----|---------------|---|---|---|
| 10 | Compound      | Structure   | Comments  | RT97+RGC axon density 14 days after ON transection (% ON axons rescued) |
|    | B             |    | Adamantyl Thioester of urea<br>Ki rotamase=149 nM<br>Clearance=? $\mu$ l/min. | 100.0%<br>$\pm$ 5.2% SEM  |
| 15 | A<br>GPI 1046 |   | Ester<br>Ki rotamase=7.5 nM<br>Clearance=63.8 $\mu$ l/min.                    | 60.5%<br>$\pm$ 3.9 SEM  |
| 20 | C             |  | Sulfonamide<br>Ki rotamase=107 nM<br>Clearance=31.1 $\mu$ l/min.              | 60.4%<br>$\pm$ 3.1% SEM   |
|    | D             |  | Pipecolic sulfonamide<br>Ki rotamase= nM<br>Clearance= $\mu$ l/min.           | 58.4%<br>$\pm$ 6.4% SEM   |
| 25 | E             |  | Ester of pipecolic acid<br>Ki rotamase=20 nM<br>Clearance=41.8 $\mu$ l/min.   | 56.6%<br>$\pm$ 9.4% SEM   |

Table V continued

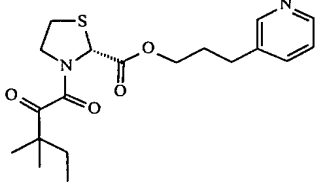
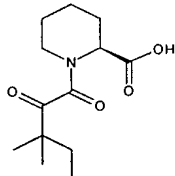
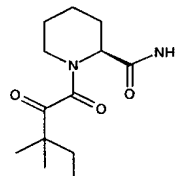
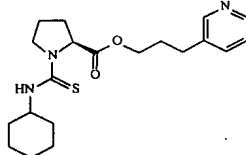
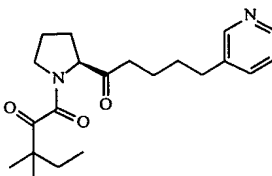
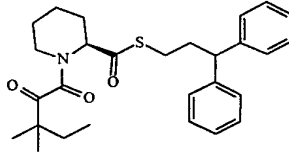
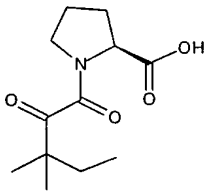
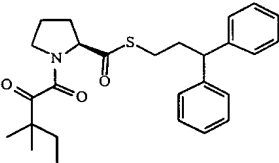
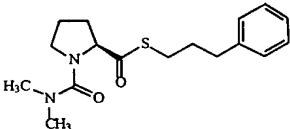
|    |          |   |  |  |
|----|----------|---|--|--|
| 5  | Compound | Structure   | Comments   | RT97+RGC<br>axon density<br>14 days after<br>ON transection<br>(% ON axons<br>rescued) |
|    | F        |    | Proline<br>heterocycle<br>Analog of GPI<br>1046<br>Ki rotamase=272<br>nM<br>Clearance=? $\mu$ l/min. | 55.1%<br>$\pm$ 5.9% SEM  |
| 10 | G        |    | Pipecolic acid<br>dimethyl ketone<br>Ki rotamase>10,000 nM<br>Clearance=? $\mu$ l/min.               | 34.0%<br>$\pm$ 4.8% SEM  |
| 15 | H        |  | Ki rotamase= nM<br>Clearance= $\mu$ l/min.   | 30.3%<br>$\pm$ 8.0% SEM  |
|    | I        |  | Ester of Thiourea<br>Ki rotamase=131 nM<br>Clearance=8.0 $\mu$ l/min.                                | 23.8%<br>$\pm$ 5.3 SEM   |
| 20 | J        |  | Ketone<br>analog of GPI 1046<br>Ki rotamase=210 nM<br>Clearance=1.5 $\mu$ l/min.                     | 15.8%<br>$\pm$ 4.8% SEM  |
|    | K        |  | Pipecolic acid Thioester<br>Ki rotamase=86 nM<br>Clearance=4.5 $\mu$ l/min.                          | 13.0%<br>$\pm$ 4.2% SEM  |



Table V continued

| Compound | Structure  | Comments   | RT97+RGC<br>axon density<br>14 days after<br>ON transection<br>(% ON axons<br>rescued) |
|----------|--|--|--|
| L        |   | Prolyl acid<br>Ki rotamase=>7743 nM<br>Clearance=5.2 µl/min. | 7.8%<br>±3.0% SEM  |
| M        |   | Thioester<br>Ki rotamase=7 nM<br>Clearance=12.5 µl/min.      | -6.3%<br>+3.9% SEM   |
| N        |  | Ki rotamase=722 nM<br>Clearance=21.9 µl/min.                 |  |

**Example 18**

**THE FKBP NEUROIMMUNOPHILIN LIGAND GPI-1046  
ENHANCES RETINAL GANGLION CELL SURVIVAL  
AND ARRESTS AXONAL DYING BACK  
FOLLOWING OPTIC NERVE TRANSECTION**

Transection of the mammalian optic nerve results in a brief period of abortive regeneration, but the majority of axotomized neurons die and the axons from many persisting ganglion cells die back beyond the optic nerve head. The present Example was designed to examine the neuroprotective effects of GPI-1046 following optic nerve transection.

Retinal ganglion cells in adult male Sprague Dawley rats were retrogradely labeled by fluorogold injection in the LGNd and four days later the optic nerves were transected 5 mm behind the globe. Groups of animals received either GPI-1046

10mg/kg/day s.c. or vehicle for 28 days. All experimental animals and controls were sacrificed 90 days after transection.

By 90 days only - 10% of the FG labeled ganglion cell population survived but less than half of these neurons maintained axons that extended past the optic nerve head, as detected with RT97 neurofilament immunohistochemistry. GPI-1046 treatment produced a moderate degree of perikaryal neuroprotection, sparing 25% of the ganglion cell population, and preserved the axons of virtually all protected neurons in the proximal stump of the transected nerve. These results indicate that treatment with the FKBP neuroimmunophilin ligand GPI-1046 produces a fundamental alteration in the pathological process following injury to CNS tracts.

These results also demonstrate that the small molecule FKBP neuroimmunophilin ligand GPI 1046 enhances neurite outgrowth in culture, enhance peripheral nerve regeneration, and stimulate sprouting within the CNS following partial deafferentation.

#### Example 19

#### **NEUROIMMUNOPHILIN LIGANDS PROMOTE RECOVERY FROM THE PERIPHERAL SENSORY NEUROPATHY ASSOCIATED WITH STREPTOZOTOCIN-INDUCED DIABETES**

Peripheral neuropathy is a common debilitating complication of Type 2 diabetes in some 30-40% of diabetic patients. Neurotrophic factors such as nerve growth factor (NGF) are known to promote survival of developing and adult neurons of the peripheral nervous system (PNS), and have also been evaluated as treatments for diabetic peripheral neuropathy. Some of the selective ligands of the neuroimmunophilin FKBP-12 such as the small molecule GPI-1046, have also been shown to promote repair and regeneration in the central and peripheral nervous systems (Proc. Nat'l. Acad. Sci. USA 94, 2019-2024, 1997).

In this Example the potential therapeutic effects of GPI-1046 were evaluated for its ability to improve sensory function in the streptozotocin-induced diabetic rat. The procedure involved using Male Wistar rats which were given a single injection of streptozotocin (65 mg/kg i.v.). Blood glucose levels were determined weekly for the first three weeks and on the last week of the experiment. Animals were evaluated weekly for signs of sensory neuropathy using the conventional hot plate and tail flick apparatus test procedures. After six weeks, treatment either with GPI-1046 or vehicle was initiated.

The results demonstrated that behavioral testing using the hot plate and the tail flick apparatus indicated improvement in latency in lesioned animals treated for 6 weeks with GPI-1046 at 10 mg/kg s.c. The results also showed that GPI-1046 ameliorates the behavioral sequelae of diabetic sensory neuropathy and may offer some relief for patients suffering from diabetic peripheral neuropathy.

#### Morris Watermaze/Aging and Memory Test Procedure

Aged rodents exhibit marked individual differences in performance on a variety of behavioral tasks, including two-choice spatial discrimination in a modified T-maze, spatial discrimination in a circular platform task, passive avoidance, radial maze tasks, and spatial navigation in a water pool.

In all of these tasks, a proportion of aged rats or mice perform as well as the vast majority of young control animals, while other animals display severe impairments in memory function compared to young animals. For example, Fischer and colleagues showed that the proportion of rats displaying significant impairments in spatial navigation increases with age, (Fischer et al. 1991b) with 8% of all 12 month old, 45% of 18 month old, 53% of 24 month old, and 90% of all 30 month old rats displaying impairments in spatial

acquisition of the Morris watermaze task relative to young controls.

Specifically, rodent spatial learning and memory decline during aging has been accepted by many investigators as an intriguing correlative animal model of human senile dementia. Cholinergic function in the hippocampus has been extensively studied as a component of spatial learning in rodents, and declining hippocampal cholinergic function has been noted in parallel with the development of learning and memory impairments. In addition, other neurotransmitter systems have been shown to contribute to spatial learning, and to decline with age, such as the dopaminergic and noradrenergic, serotonergic, and glutamatergic systems.

Also, reports on age-related deficits of hippocampal long-term potentiation (LTP)-induction, a reduction in theta rhythm frequency, a loss of experience-dependent plasticity of hippocampal place-units, and reductions in hippocampal protein kinase C are in keeping with the concept that no single underlying pathology can be identified as the cause of age-related behavioral impairment in rodents. However, the various experimental therapeutic approaches that have been undertaken to improve memory function in aged rodents have been somewhat slanted towards the cholinergic hypothesis.

The Morris watermaze is widely used for assessing spatial memory formation and retention in experimental animals. The test depends on the animal's ability to utilize spatial visual information in order to locate a submerged escape platform in a water tank. It is important that the tank itself be as devoid of specific visual features as possible - thus, it is always circular in shape, the sides are kept smooth and in uniform dull colors, and the water is rendered opaque with nontoxic watercolour pigment or powdered milk. This is to ensure that the animal navigates only by the use of more distant visual cues, or by the use of intra-maze cues specifically provided by the experimenter. The

tank is filled to a level which forces the animal to swim actively. Normal mice and rats react aversively to the swimming part of the test and will climb onto, and remain on, an escape platform from which they are removed to a heated  
5 resting cage.

If the platform is visible (i.e. above the surface), animals placed in the tank will quickly learn to home in on the platform and climb out onto it. Testing with a visible platform will also ensure that the experimental animals are  
10 not blind and show sufficient motivation and stamina to perform the task, which can be important in experiments involving aged rodents. If the platform is invisible (i.e. submerged just below the surface), normal animals learn to use distant visual cues in the test room for orientation in  
15 the test tank, and, when placed in the tank, will quickly home in on the approximate location of the platform and circle in that area until the platform is found. The animals' path, speed, and swim time are tracked with a ceiling camera for later computerized analysis. Over the  
20 course of several successive trials, spatial learning can therefore be defined as a drop of distance swum, or time elapsed, from placement in the tank until escape onto the invisible platform.

The test can be adapted to assess several aspects of  
25 spatial memory: a) acquisition of a cued task, where the animal's ability to link one visual cue directly with the escape platform depends on cortical function (i.e. a ball is suspended over the escape platform and the animal learns to follow this cue to find the platform); b) acquisition of a  
30 spatial task, where the animal's ability to learn the location of a submerged escape platform based on a combination of distant visual cues is dependent upon hippocampal function (i.e. the animal learns to triangulate its position in the tank by visually aligning the paper-tower  
35 dispenser with the door and ceiling lamp); c) retention of a

successfully acquired spatial task, which is predominantly dependant on cortical function (i.e. the animal must remember the spatial location of the platform over several weeks); d) a hippocampus-dependant reversal task where the animals must reacquire a new spatial platform location (i.e. the platform is moved to a new location between swim trials and the animal must abandon its previous search strategy and acquire a new one).

These different modifications of the Morris watermaze procedure can be applied in sequence to the same set of experimental animals and allow for a thorough characterization of their spatial memory performance and its decline with normal ageing. Moreover, such a series of sequential memory tests sheds some light on the functional integrity of the specific brain systems involved in the acquisition and retention of spatial memory (e.g. rats with cholinergic lesions of the hippocampus may remember a platform location acquired weeks before, but persevere over the old platform location after the platform is moved).

20

#### Example 20

##### **EFFECTS OF CHRONIC GPI-1046 ADMINISTRATION ON SPATIAL LEARNING AND MEMORY IN AGED RODENTS**

25 This Example shows the effects of chronic treatment with the systemically available FKBP-ligand GPI-1046 on spatial learning and memory in aged rodents.

The procedure involved using three-month old (young) and 18-19 month old male C57BL/6N-Nia (aged) mice which habituated to the well known and conventional Morris watermaze during a 4 trials/day, 3-4 day visible platform training phase. Subsequent spatial acquisition testing was conducting as follows: All mice were given 4 trials/day (block), for 5 days. Maximum swim time was 90 seconds. Aged mice were allocated to an "aged impaired" group if their performance during blocks 4 or 5 of the acquisition phase was

35

>1 S.D. above the mean of "young" mice, and to an "aged non-impaired" group if their performance was < 0.5 S.D. above the mean of "young" mice. Aged groups were then split into statistically similar "GPI-1046" and "vehicle" groups.

5       Daily treatment with 10mg/kg GPI-1046 was initiated 3 days after the end of acquisition training, and continued through retention testing. Retention testing began after 3 weeks of dosing using the same methods as the acquisition phase. Swim Distances (cm) were analyzed in a 7 X 5 ANOVA  
10 including Groups and Blocks (1-5) as factors in the analysis, treating Blocks as a repeated measure.

      The results showed that planned contrasts revealed that there were significant differences between the "young", and "aged impaired-vehicle and GPI-1046" treated groups at the end  
15 of the acquisition phase,  $F_{1,58} = 26.75$ ,  $P=0.0001$ , and  $F_{1,58} = 17.70$ ,  $P=0.0001$  respectively. While there were no significant differences between the two "aged impaired" groups,  $F_{1,58} = 0.67$ ,  $P = 0.42$ . During retention testing, however, "aged impaired-vehicle" treated animals performed  
20 significantly poorer than "aged impaired - GPI-1046", and "young" animals,  $F_{1,69} = 8.11$ ,  $P = 0.006$ , and  $F_{1,69} = 25.45$ ,  $P = 0.0001$  respectively. There was no longer any statistically significant difference between the "young" and "aged impaired" - GPI-1046" treated groups during the  
25 retention phase,  $F_{1,69} = 3.09$ ,  $P = 0.08$ . In summary, systemic treatment with GPI-1046 significantly enhanced spatial memory performance of mice with age-related spatial memory impairments.

      The invention being thus described, it will be obvious  
30 that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention and all such modification are intended to be included within the scope of the following claims.

What is claimed is:

1. A method for treating a vision disorder, improving  
5 vision, treating memory impairment or enhancing memory  
performance in an animal, which comprises administering to  
said animal an effective amount of a N-linked sulfonamide of  
an N-heterocyclic carboxylic acid or isostere thereof.

10 2. The method of claim 1, wherein the N-linked  
sulfonamide of an N-heterocyclic carboxylic acid or isostere  
thereof is immunosuppressive or non-immunosuppressive.

3. The method of claim 1, wherein the N-linked  
15 sulfonamide of an N-heterocyclic carboxylic acid or isostere  
thereof has an affinity for an FKBP-type immunophilin.

4. The method of claim 3, wherein the FKBP-type  
immunophilin is FKBP-12.

20

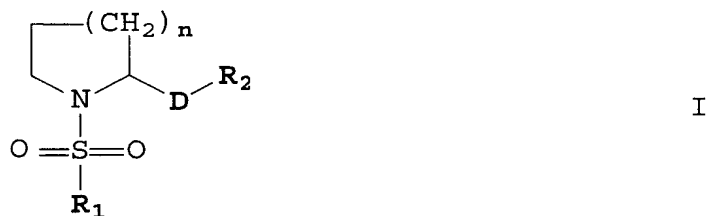
5. The method of claim 1, wherein the vision disorder  
is selected from the group consisting of: visual impairments;  
orbital disorders; disorders of the lacrimal apparatus;  
disorders of the eyelids; disorders of the conjunctiva;  
25 disorders of the cornea; cataract; disorders of the uveal  
tract; disorders of the retina; disorders of the optic nerve  
or visual pathways; free radical induced eye disorders and  
diseases; immunologically-mediated eye disorders and  
disorders; eye injuries; and symptoms and complications of eye  
30 disease, eye disorder, or eye injury.

6. The method of claim 1, which is for improving  
naturally-occurring vision in an animal, in the absence of  
any ophthalmologic disorder, disease, or injury.

35



7. The method of claim 1, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof is a compound having the formula (I):



5

where

n is 1-3;

R<sub>1</sub> is selected from the group consisting of hydrogen, C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>9</sub> straight or branched chain alkenyl, aryl, heteroaryl, carbocycle, or heterocycle;

10 D is a bond, or a C<sub>1</sub>-C<sub>10</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>10</sub> alkenyl or C<sub>2</sub>-C<sub>10</sub> alkynyl;

R<sub>2</sub> is a carboxylic acid or a carboxylic acid isostere; wherein said alkyl, alkenyl, alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or carboxylic acid isostere is optionally substituted with one or more substituents selected from R<sup>3</sup>, where

15

R<sup>3</sup> is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl, C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>6</sub> straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or CO<sub>2</sub>R<sup>4</sup> where R<sup>4</sup> is hydrogen or C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl or alkenyl;

20

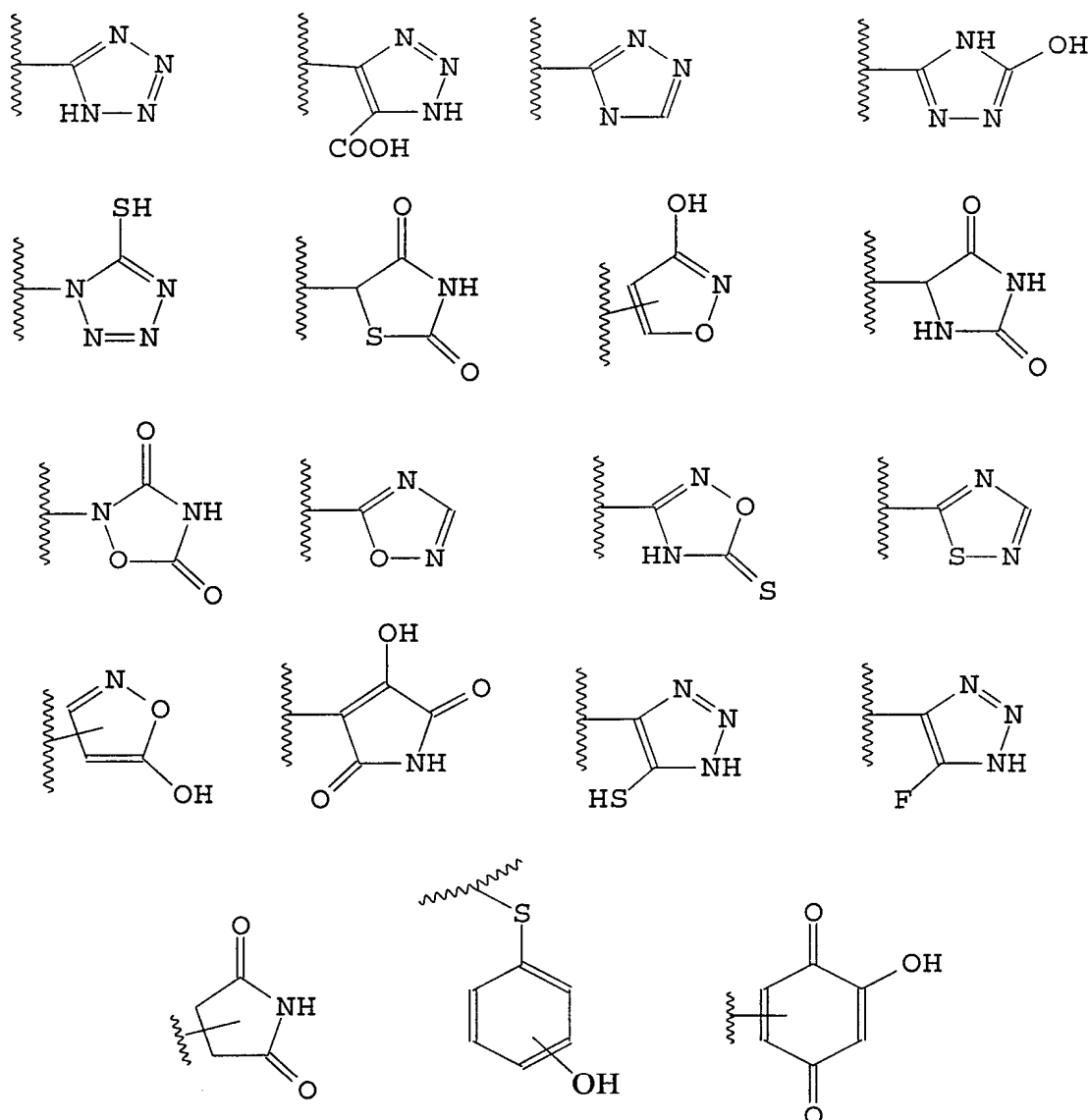
25 or a pharmaceutically acceptable salt, ester or solvate thereof.

8. The method of claim 7, wherein R<sub>2</sub> is a carbocycle or heterocycle containing any combination of CH<sub>2</sub>, O, S, or N in any chemically stable oxidation state, where any of the atoms of said ring structure are optionally substituted in one or more positions with R<sup>3</sup>, wherein

30

$R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1$ - $C_6$  straight or branched chain alkyl,   
 5  $C_2$ - $C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, and  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1$ - $C_9$  straight or branched chain alkyl or alkenyl.

9. The method of claim 7, wherein  $R_2$  is selected from   
 10 the group below:



where the atoms of said ring structure  $R_2$  may be optionally substituted at one or more positions with  $R^3$ , wherein  $R^3$  is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl, alkylthio, sulfonyl,  $C_1$ - $C_6$  straight or branched chain alkyl,  $C_2$ - $C_6$  straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, and  $CO_2R^4$  where  $R^4$  is hydrogen or  $C_1$ - $C_9$  straight or branched chain alkyl or alkenyl.

10

10. The method of claim 7, wherein  $R_2$  is selected from the group consisting of  $-COOH$ ,  $-SO_3H$ ,  $-SO_2HNR^3$ ,  $-PO_2(R^3)_2$ ,  $-CN$ ,  $-PO_3(R^3)_2$ ,  $-OR^3$ ,  $-SR^3$ ,  $-NHCOR^3$ ,  $-N(R^3)_2$ ,  $-CON(R^3)_2$ ,  $-CONH(O)R^3$ ,  $-CONHNHSO_2R^3$ ,  $-COHNSO_2R^3$ , and  $-CONR^3CN$ .

15

11. The method of claim 7, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof is selected from the group consisting of:

(2S)-1-(phenylmethyl)sulfonyl-2-hydroxymethyl pyrrolidine;  
20 (2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinetetrazole; and  
compounds 1-97 disclosed herein.

12. A pharmaceutical composition for treating a vision disorder, improving vision, treating memory impairment or enhancing memory performance in an animal, comprising:

- 25 a) an effective amount for treating a vision disorder, improving vision, treating memory impairment or enhancing memory performance in an animal of a N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof; and  
30 b) a pharmaceutically acceptable carrier.

13. The pharmaceutical composition of claim 12, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof is immunosuppressive or non-

35

immunosuppressive.

14. The pharmaceutical composition of claim 12, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof has an affinity for an FKBP-type immunophilin.

15. The pharmaceutical composition of claim 14, wherein the FKBP-type immunophilin is FKBP-12.

10

16. The pharmaceutical composition of claim 12, wherein the vision disorder is selected from the group consisting of: visual impairments; orbital disorders; disorders of the lacrimal apparatus; disorders of the eyelids; disorders of the conjunctiva; disorders of the cornea; cataract; disorders of the uveal tract; disorders of the retina; disorders of the optic nerve or visual pathways; free radical induced eye disorders and diseases; immunologically-mediated eye disorders and disorders; eye injuries; and symptoms and complications of eye disease, eye disorder, or eye injury.

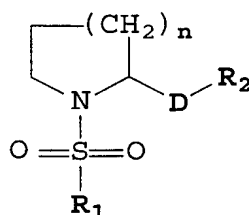
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17. The pharmaceutical composition of claim 12, which is for improving naturally-occurring vision in an animal, in the absence of any ophthalmologic disorder, disease, or injury.

25

18. The pharmaceutical composition of claim 12, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid or isostere thereof comprises a compound of formula (I):

30



I

where

n is 1-3;

R<sub>1</sub> is selected from the group consisting of hydrogen, C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>9</sub> straight or branched chain alkenyl, aryl, heteroaryl, carbocycle, or heterocycle;

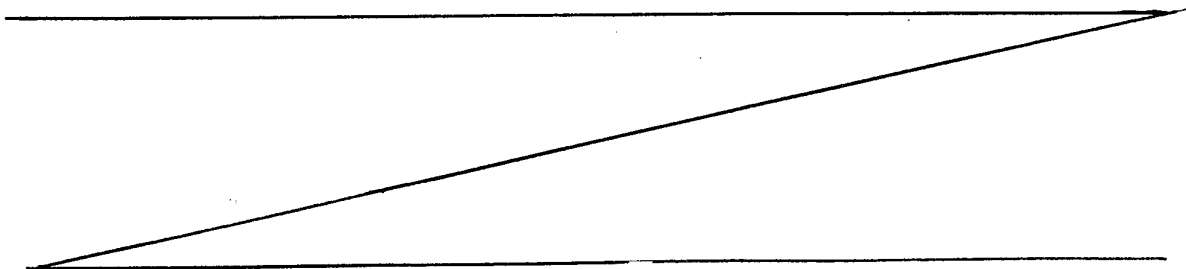
5 D is a bond, or a C<sub>1</sub>-C<sub>10</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>10</sub> alkenyl or C<sub>2</sub>-C<sub>10</sub> alkynyl;

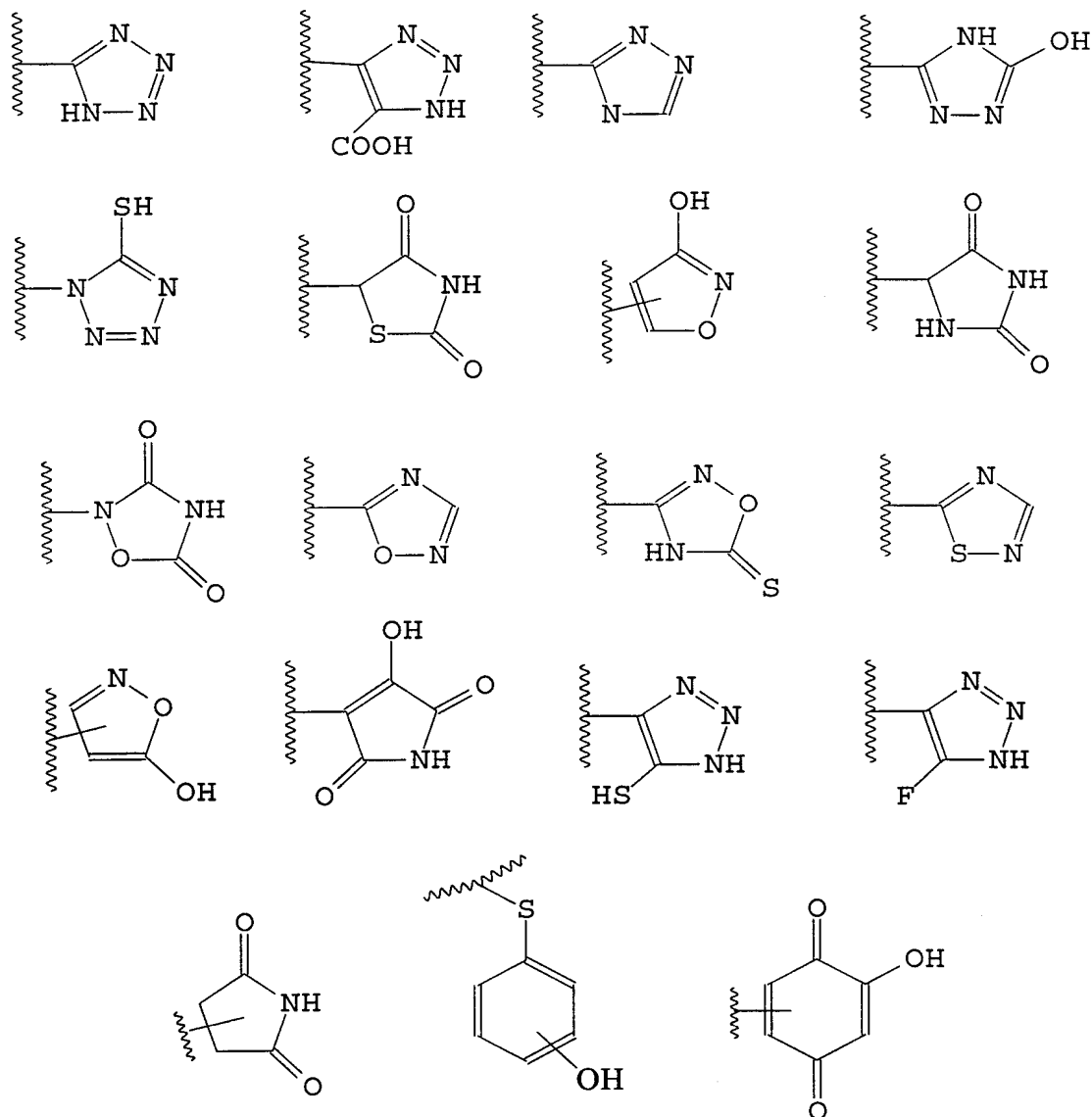
R<sub>2</sub> is a carboxylic acid or a carboxylic acid isostere; wherein said alkyl, alkenyl, alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or carboxylic acid isostere is  
10 optionally substituted with one or more substituents selected from R<sup>3</sup>, where

R<sup>3</sup> is hydrogen, hydroxy, halo, haloalkyl, thiocarbonyl, alkoxy, alkenoxy, alkylaryloxy, aryloxy, arylalkyloxy, cyano, nitro, imino, alkylamino, aminoalkyl, sulfhydryl, thioalkyl,  
15 alkylthio, sulfonyl, C<sub>1</sub>-C<sub>6</sub> straight or branched chain alkyl, C<sub>2</sub>-C<sub>6</sub> straight or branched chain alkenyl or alkynyl, aryl, heteroaryl, carbocycle, heterocycle, or CO<sub>2</sub>R<sup>4</sup> where R<sup>4</sup> is hydrogen or C<sub>1</sub>-C<sub>9</sub> straight or branched chain alkyl or alkenyl; or a pharmaceutically acceptable salt, ester or solvate  
20 thereof.

19. The pharmaceutical composition of claim 18, wherein R<sub>2</sub> is a carbocycle or heterocycle containing any combination of CH<sub>2</sub>, O, S, or N in any chemically stable oxidation state,  
25 wherein any of the atoms of said ring structure are optionally substituted in one or more positions with R<sup>3</sup>.

20. The pharmaceutical composition of claim 18, wherein R<sub>2</sub> is selected from the following group:





where the atoms of said ring structure may be optionally substituted at one or more positions with  $R^3$ .

5

21. The pharmaceutical composition of claim 18, wherein  $R_2$  is selected from the group consisting of:  $-\text{COOH}$ ;  $-\text{SO}_3\text{H}$ ;  $-\text{SO}_2\text{HNR}^3$ ;  $-\text{PO}_2(\text{R}^3)_2$ ;  $-\text{CN}$ ;  $-\text{PO}_3(\text{R}^3)_2$ ;  $-\text{OR}^3$ ;  $-\text{SR}^3$ ;  $-\text{NHCOR}^3$ ;  $-\text{N}(\text{R}^3)_2$ ;  $-\text{CON}(\text{R}^3)_2$ ;  $-\text{CONH}(\text{O})\text{R}^3$ ;  $-\text{CONHNHSO}_2\text{R}^3$ ;  $-\text{COHNSO}_2\text{R}^3$ ; and  $-\text{CONR}^3\text{CN}$ .

10

22. The pharmaceutical composition of claim 18, wherein the N-linked sulfonamide of an N-heterocyclic carboxylic acid

or isostere thereof is selected from the group consisting of:  
(2S)-1-(phenylmethyl)sulfonyl-2-hydroxymethyl pyrrolidine;  
(2S)-1-(phenylmethyl)sulfonyl-2-pyrrolidinetetrazole; and  
compounds 1-97 disclosed herein.

FIG. 1A

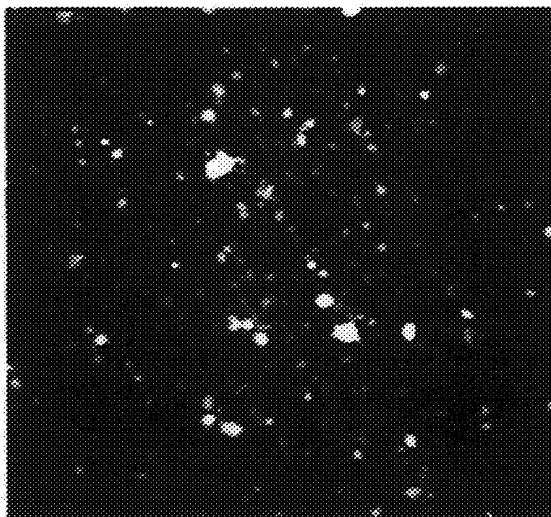


FIG. 1B

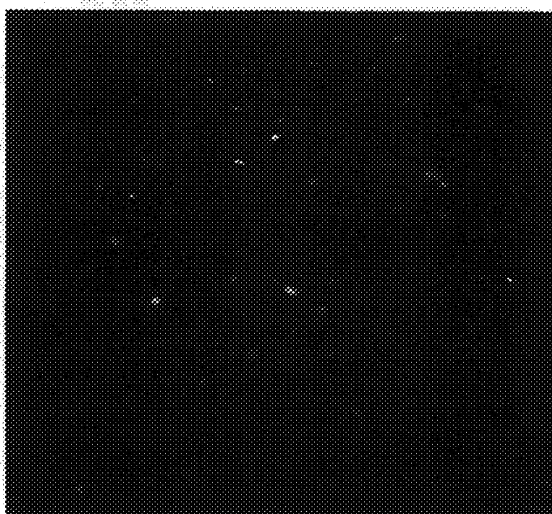


FIG. 1C

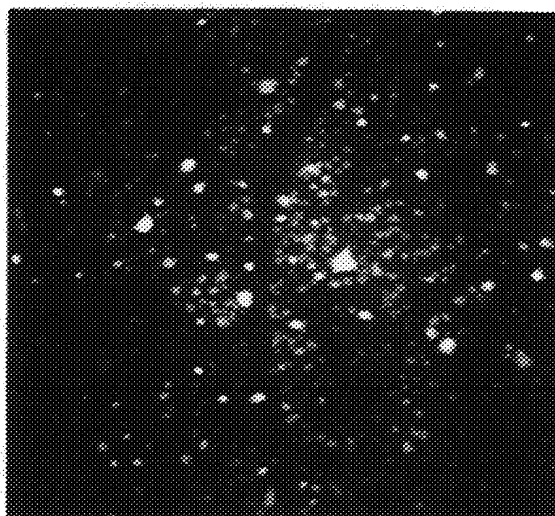




FIG. 2A

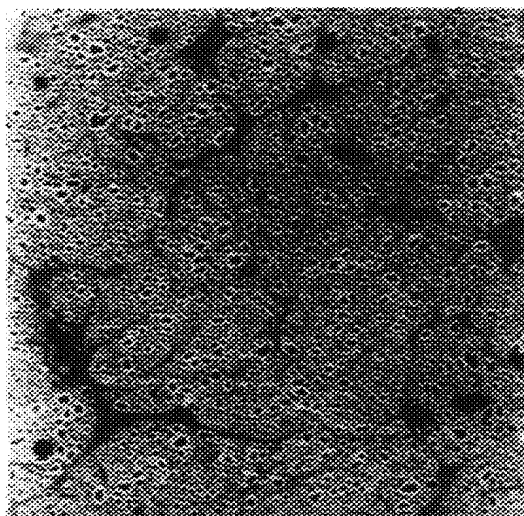


FIG. 2B

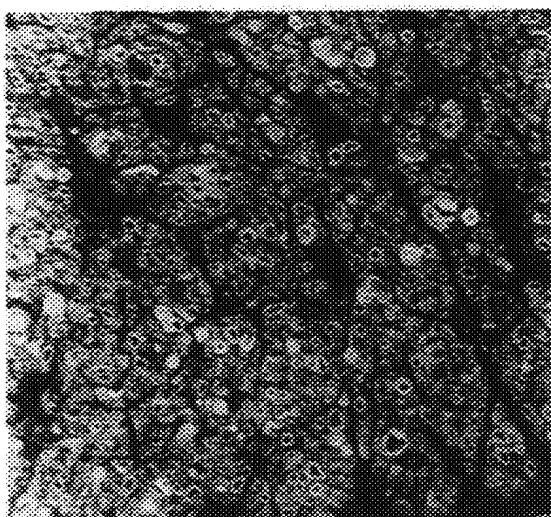


FIG. 2C



FIG. 3A



FIG. 3B

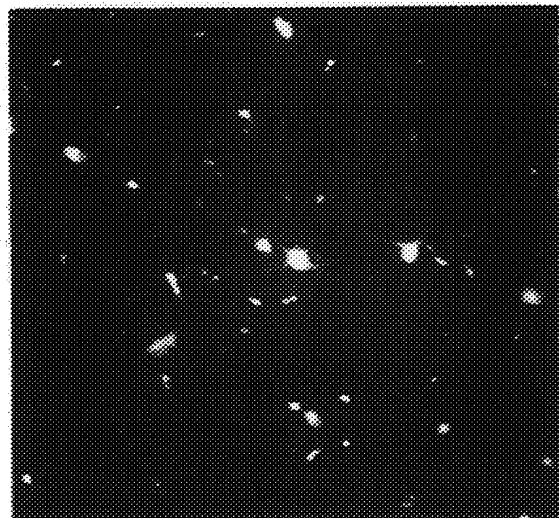


FIG. 4A



FIG. 4B



FIG. 4C

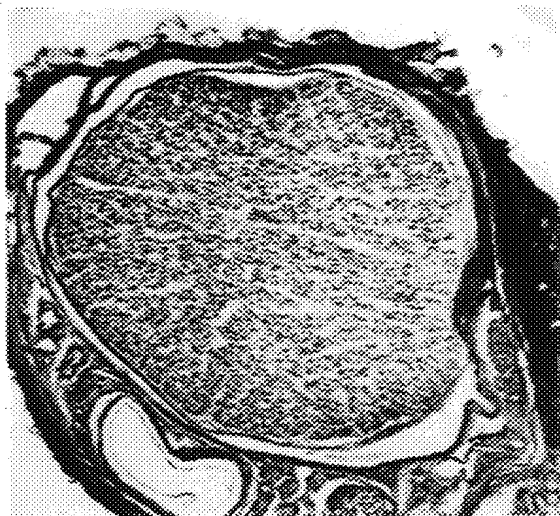


FIG. 4D

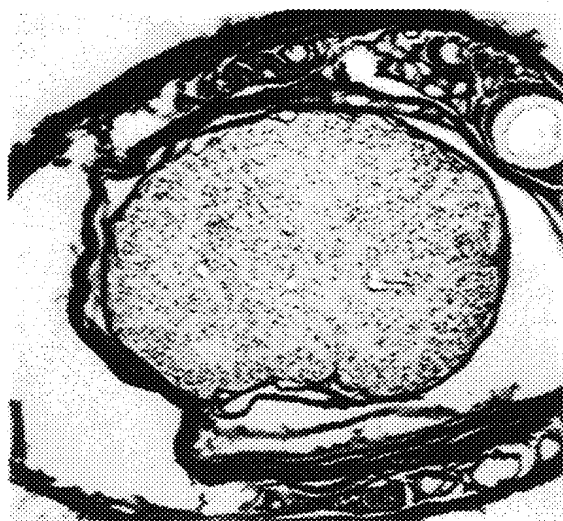


FIG. 5A



FIG. 5B

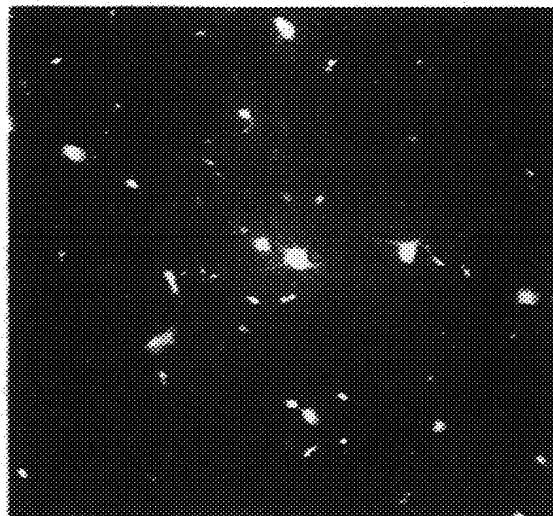


FIG. 5C

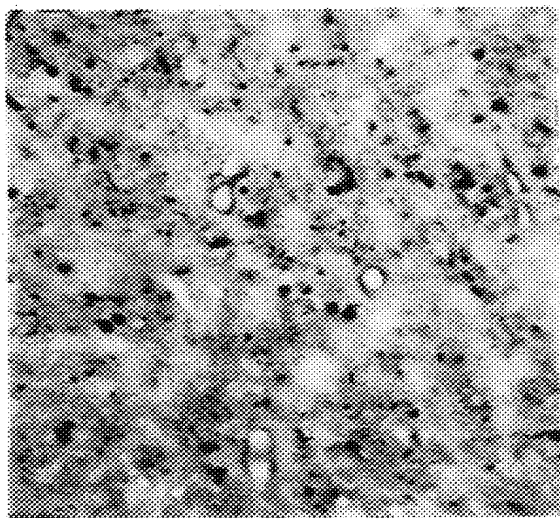


FIG. 5D

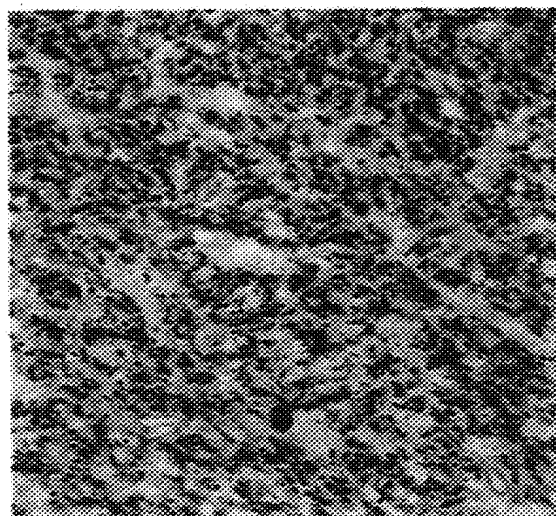


FIG. 6A

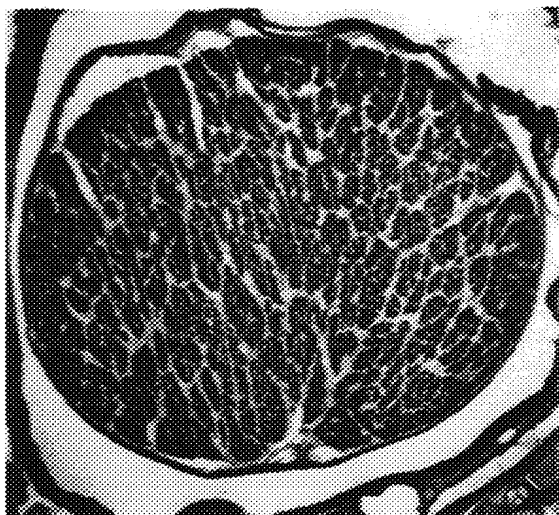


FIG. 6B



FIG. 6C

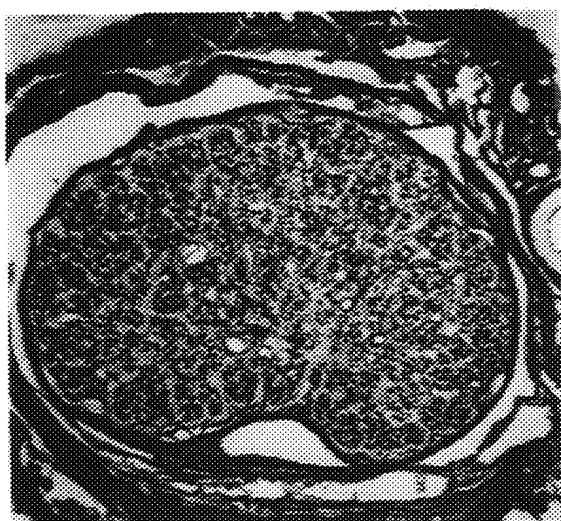


FIG. 6D

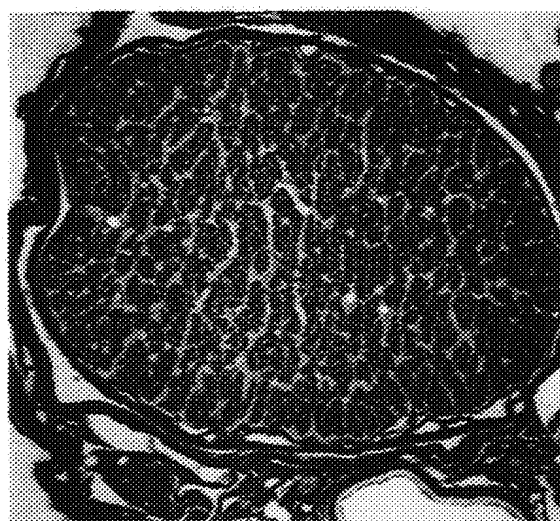


FIG. 7

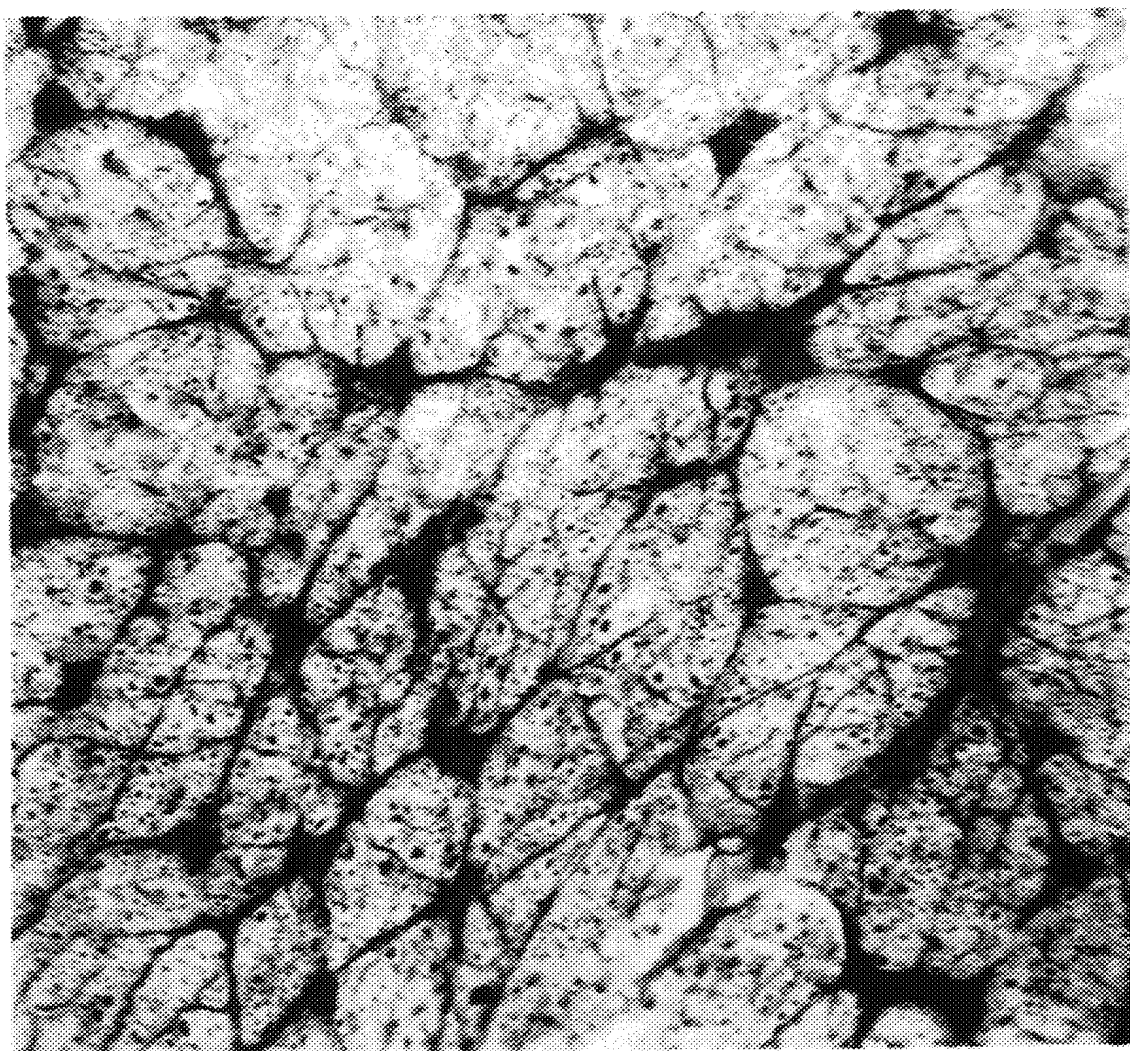


FIG. 8A

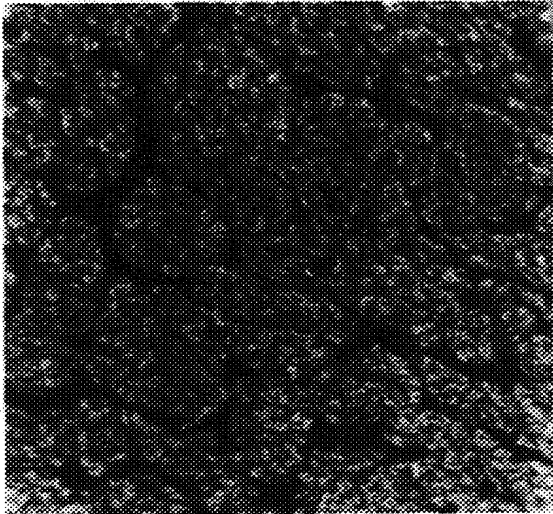


FIG. 8B

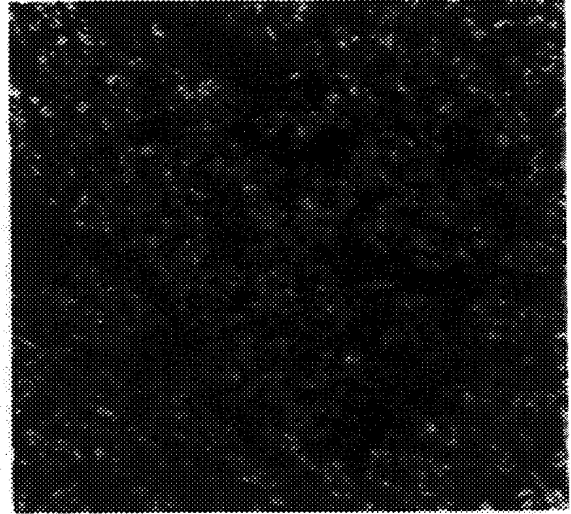


FIG. 8C

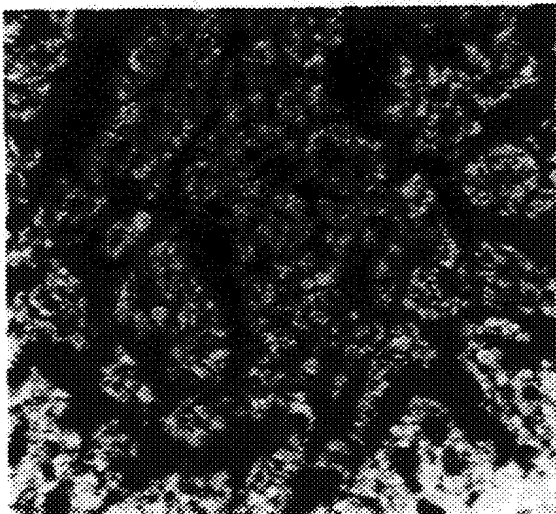


FIG. 8D

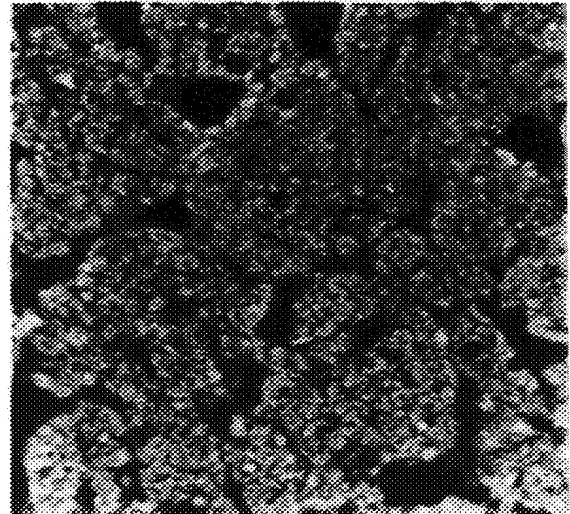


FIG. 9A

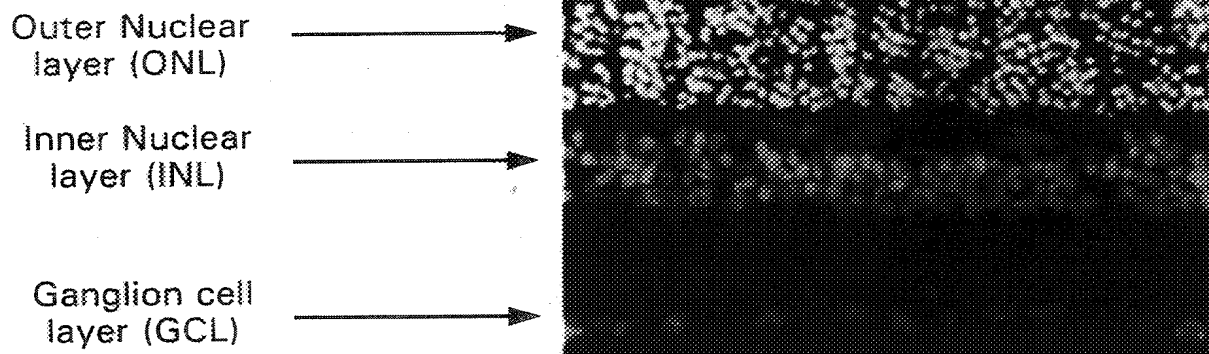


FIG. 9B

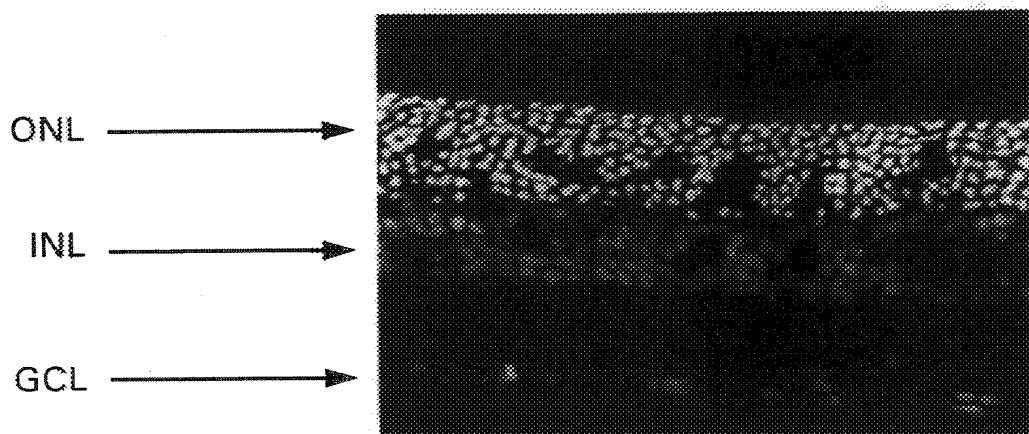


FIG. 9C

